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The Atlantic Salmon Workshop, Qualicum Beach, British Columbia, March 7-9, 1990

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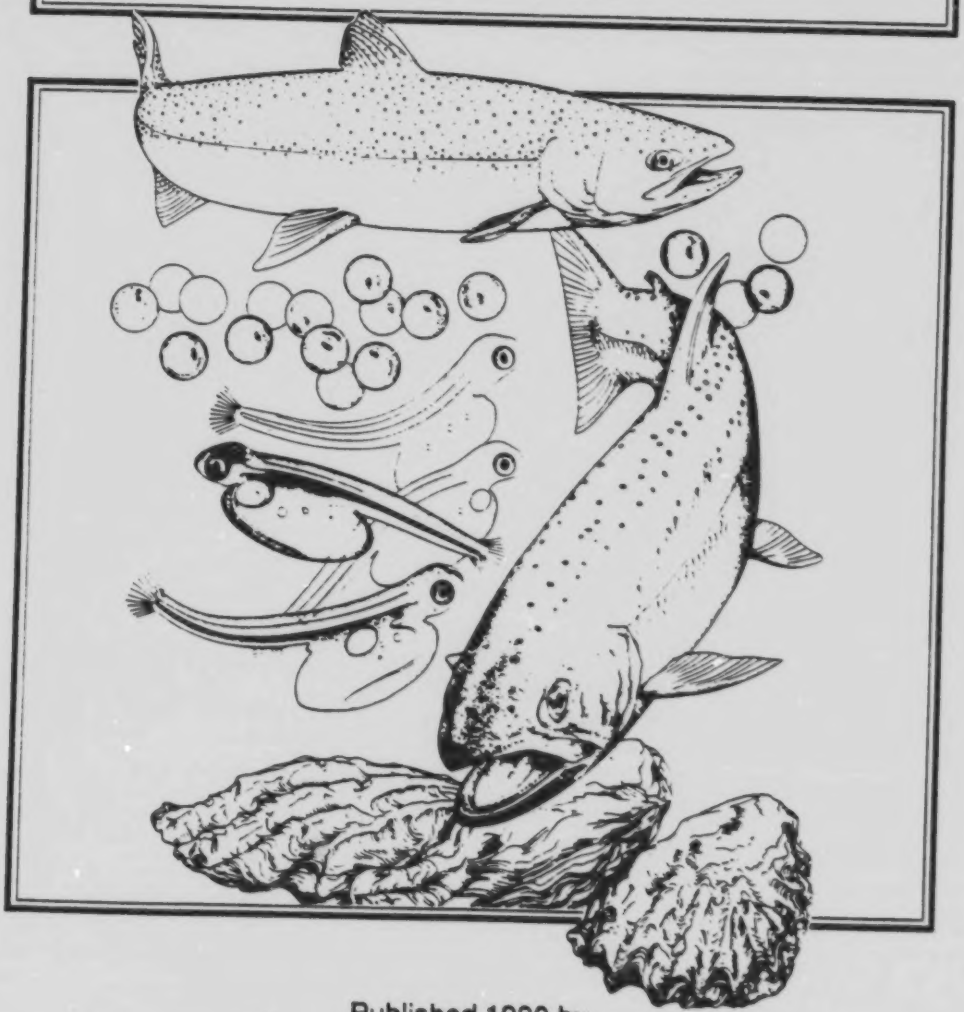
Aquaculture Industry Development Report

The Atlantic Salmon Workshop Qualicum Beach, British Columbia

March 7-9, 1990



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THE ATLANTIC SALMON WORKSHOP

Qualicum College Inn, Qualicum Beach, B.C., March 7 - 9 1990

This publication is a summary of the presentations and discussion at the Atlantic Salmon Workshop held at the Qualicum College Inn at Qualicum Beach, from March 7 to 9, 1990. It is one of a series of such workshop summaries which are intended to document industry development. The information provided is by no means the last word on any topic but is meant to guide the reader. Over the next 3 to 5 years, industry practices will become more defined. However, there will always be a need to interpret standard practices for specific situations. This is when the skill of the fish farmer will determine success of individual operations.

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TABLE OF CONTENTS

Overview of Atlantic Salmon Production 1
Dr. Al Castledine

Egg-take, Incubation, Swim-up and Aspects of Smoltification. Gene Henderson 4

Similarities and Differences Between Atlantic and Pacific Salmon. John Holder 11

Freshwater Production Practices at Sea Farm Canada. Bill Drope 16

Disease in Freshwater Rearing. Dr. Steve Backman . . . 18

Saltwater Introduction and East Coast Culture Practices. Gene Henderson 21

Seawater Grow-out Techniques. Kim Garety 24

The Nutrition and Feeding of Atlantic Salmon 27
Dr. Viv Crampton

Management of Sea Lice. Dr. Peter Smith 37

Diseases of Atlantic Salmon Reared in Net-pens in the Pacific Northwest. Dr. Michael Kent 42

The Impact of Harmful Phytoplankton on Atlantic Salmon. Ed Black 45

Production Cost and Return Considerations in Atlantic Versus Pacific Salmon. Dr. John Spence,Dr. Ted Needham 49

Marketing of Atlantic Salmon. Knut Skabo 57

Northeast U.S. Atlantic Salmon Farming Industry Current Practices and Marketing Objectives. Dr. Jim Anderson 60

History of Atlantic Salmon Imports to the West Coast Since 1983. Gary Hoskins 67

Guidelines for Lake Net-pen Rearing of Atlantic Salmon Smolts. George Reid 72

THE ATLANTIC SALMON WORKSHOP

Overview of Atlantic Salmon Production

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The Atlantic salmon is a beautiful fish, traditionally known as the king of fish and the fish of kings. The native range of the Atlantic salmon is from the eastern United States and Canada, with a freshwater population in Lake Ontario, wild runs in Greenland, Iceland, Scandinavia and in Europe south to Portugal. Interestingly, both North American and European strains feed in the North Atlantic off the Greenland coast.

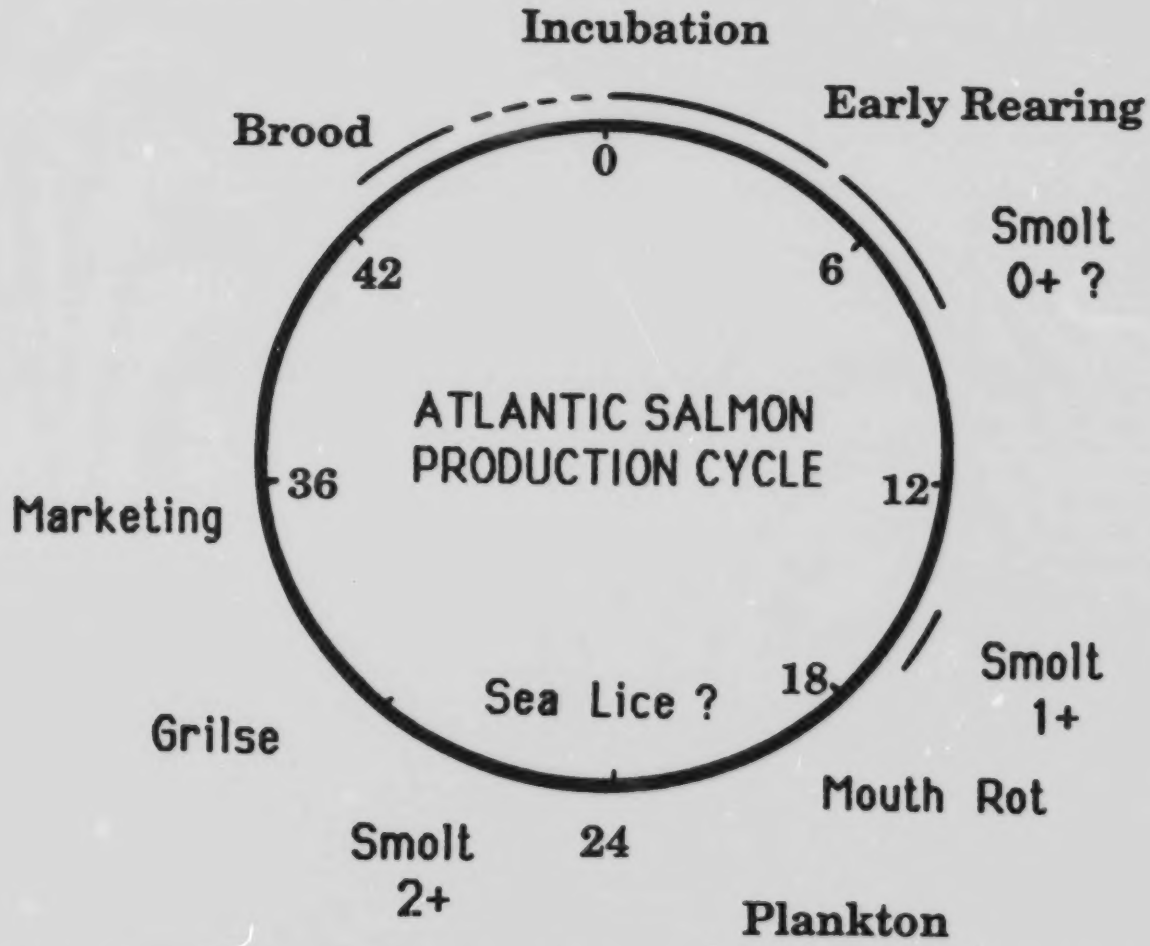
Attempts have been made to introduce Atlantic salmon into New Zealand, the Republic of South Africa, Argentina (a landlocked variety), and in Oregon for a recreation fishery. An attempt to introduce Atlantics into the Cowichan River in British Columbia failed. Historically, Atlantic salmon have been moved around the world almost without question. Presently, they have been introduced for fish culture purposes to Tasmania, Chile, British Columbia and Washington.

Figure 1 is a simple diagram of the production/life cycle of the Atlantic salmon that may assist us in our discussions over the next two days. In the wild, Atlantics start their life in the fall of the year as fertilized eggs in the gravel of their natal stream. They hatch in the gravel, but remain there for several weeks as alevins, feeding off their yolk sac until late winter or early spring when they emerge into the open stream and begin one, two or three years of freshwater rearing. In the Ungava region (Northern Quebec), Atlantic juveniles may spend up to 7 years in freshwater rearing prior to leaving the freshwater habitat.

Like Pacific salmon, when Atlantic salmon become physiologically ready to enter saltwater they are called "smolts". The smolts migrate to the ocean where they typically rear for one year or more prior to returning to the natal stream to spawn. Precocious fish that return to the river after only one winter at sea are called grilse. Because they mature early, grilse may be a liability to the fish farmer.

Problems associated with the sea pen culture of Atlantic salmon are mouth rot, plankton blooms and sea lice. Sea lice is particularly a problem in Europe, where control has proven difficult.

Figure 1. Diagram of a typical Atlantic salmon production/life cycle with significant events (time indicated in months).



World production of Atlantic salmon reached a total of 165,800 tonnes in 1989 (Table 1). This exceeds the production of all other salmon species (Figure 2).

Different strains of Atlantic salmon perform differently in culture. Figure 3, from the AAC Bulletin, Edition 89-4, illustrates how growth rate varies between three strains of Norwegian and Scottish Atlantics. In addition to importing strains which perform well, there appears to be good potential to develop breeding programs for Atlantics.

Table 1. World production of Atlantic salmon in 1989.

Country	Production in Tonnes
Norway	117,000
Scotland	29,000
Ireland	6,200
Faroes	5,000
Canada - East Coast	3,500
- West Coast	800
Iceland	2,000
Chile	?
U.S. - Washington	1,300
Tasmania	1,000
	165,000+

Figure 2. World production of high value salmon species in 1988.

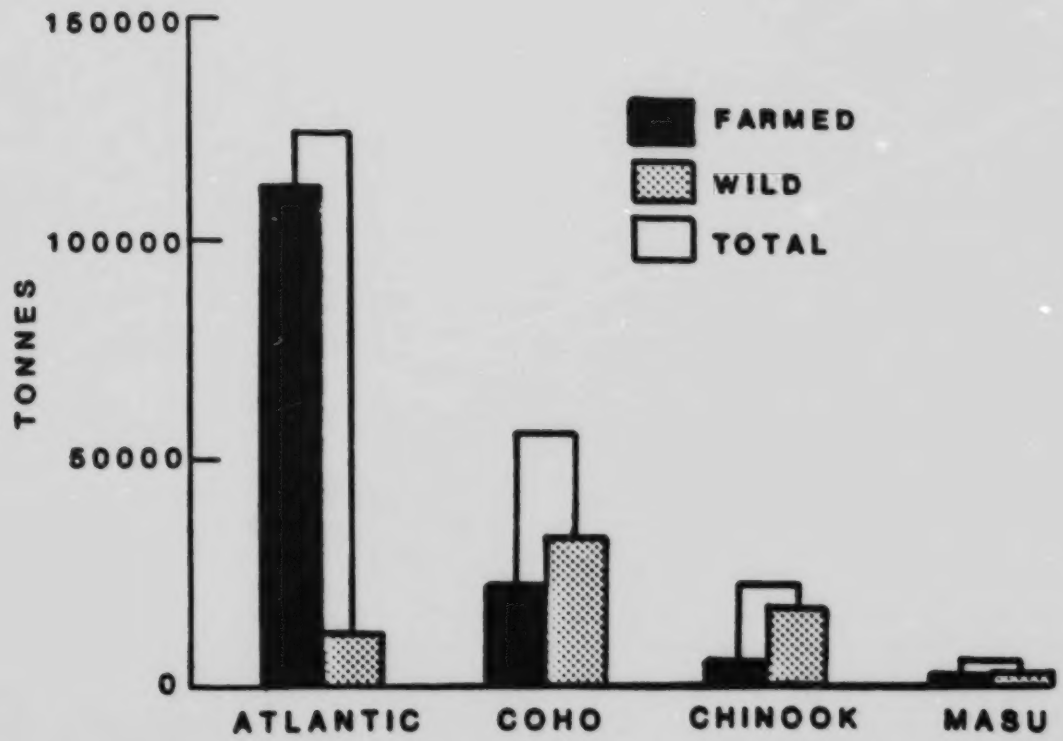
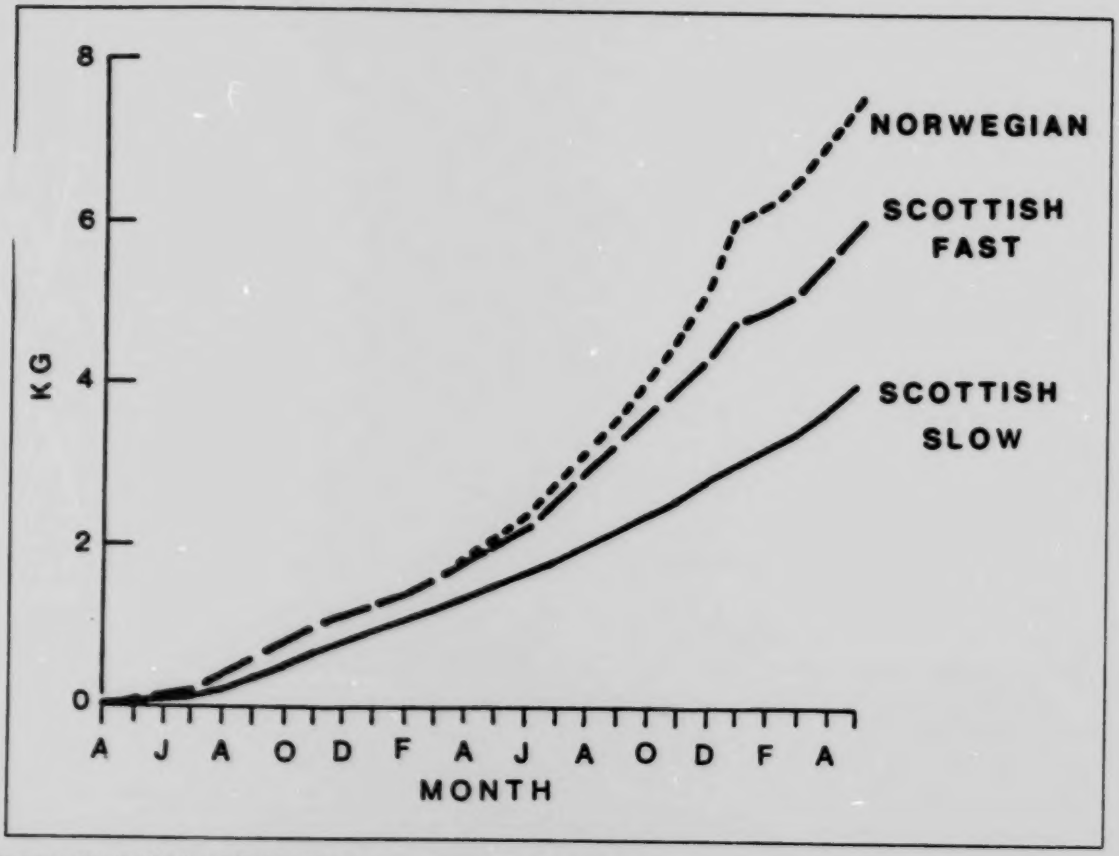


Figure 3. Comparison of growth rates between three strains of Atlantic salmon.



(Source: AAC Bulletin, Edition 89-4)

Session 1 - Freshwater Technical Considerations

Moderator - Al Castledine

Egg-take, Incubation, Swim-up and Aspects of Smoltification

Gene Henderson
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The highest concentration of farms in New Brunswick is in Limekiln Bay. The demonstration farm was built in this area in 1986.

THE ATLANTIC SALMON WORKSHOP

The New Brunswick Salmon Grower's Association supports a broodstock development program by a contribution of $50,000 annually. Smolts from a genetic program conducted by the Atlantic Salmon Federation are maintained at the Atlantic Salmon Demonstration and Development Farm. These smolts are individually marked and broodstock selection and matings are carried out under supervision of geneticists from the Atlantic Salmon Federation. We prefer Saint John River salmon for their high growth rate and very low grilse rate. The industry has a high rate of survival from smolt to market, in the order of 90 percent.

An important criteria used in selecting broodstock is that it be screened for disease. The screening program consists of sampling and testing ovarian fluid for pathogens and keeping eggs separate until the female is declared clean.

Low egg survival was experienced in salmon grown in sea cages until about 2 or 3 years ago. Although controlled experiments have not been conducted, experience has demonstrated that the cessation of feeding 2 months prior to taking eggs, and the introduction of an improved broodstock diet, have resulted in significantly improved but still variable (70 - 90%) egg survival. (This variability is also seen in the wild and may always be a characteristic of Atlantic salmon farming). Whether the improvement was due to starving the fish prior to egg take or to the improvement of the broodstock diet is unclear, since no controls were used.

The supply of eggs is not a limiting factor. Extra broodstock is set aside and the fecundity in a large female is 10,000 to 12,000 eggs. This relatively abundant supply is used to compensate for elevated mortality that may occur.

Broodstock is stripped on the farm to avoid spreading disease to the hatchery and to avoid the requirement for expensive freshwater holding facilities. It is important that saltwater not contaminate the eggs or milt, so the fish are rinsed well with freshwater. Only females are anaesthetized. In the past, fertilization took place on the farm, but now the gametes are transported to the hatchery. Improved results have been realized.

After eggs are fertilized, they are water hardened then laid into various types of incubators such as Heath Trays, California Trays and others, the choice is a matter of preference. Important factors in successful incubation include good quality, well oxygenated water with low silt load, and that light be kept from the eggs.

Malachite green is almost never used in fungus control. Dead

eggs are removed by hand from an early stage after fertilization to avoid the growth of fungus. We find that with the proper care, this can be done without incurring additional mortality. Eggs are shocked at the eyed stage and blanks removed.

At swim-up, feeding can be a problem. Advances in bringing emergent fry onto feed include better starter diet, improved temperature regime and perhaps some domestication among the stock. After two generations of breeding, the fry are starting to feed significantly better than the wild stock.

Estimating the time of first feeding is accomplished in several ways. A common method is to estimate when two thirds of the yolk is used up and start presenting feed at this stage. My preference is to incubate in Astro turf and present feed when the fry swim-up. Using this method, it is obvious when the fry are ready to feed.

Emergence is dependent on the water temperature. In New Brunswick, surface water temperatures are very cold and fry reared on surface water do not swim-up until May or early June. At 8 degrees Celsius, Atlantic salmon eggs take 34 days to eye, another 25 days to hatch and another 42 days to swim-up, for a total of about 100 days.

Our experience is that 8 degrees is the optimum rearing temperature. To accelerate development, incubation temperature can be increased to 12 degrees, but mortality will increase. A judgment must be made between the desirability of lower mortality in 8 degree water and the more rapid development at higher temperatures. In any case, it must be decided in the fall when swim-up is desired and the temperature regime adjusted accordingly.

Optimum rearing temperatures at swim-up are between 14 and 16 degrees Celsius. These high temperatures promote good feeding response, high survival and rapid growth. A higher proportion of S_1 smolts (smolting in the second spring) are realized where incubation temperatures are 8 degrees and initial rearing temperatures are 16 degrees. To achieve these temperatures, heat pumps and exchangers are utilized until June when surface water temperatures increase. If water cannot be heated and incubation temperatures are low so that swim-up does not occur until late May or June, there will be few S_1 smolts. In any case, only about 60 percent S_1 smolts are expected and the rest smolt in the next year.

Questions and Answers

Q - What is the success of smolt transfer to saltwater?

A - We use direct transfer from fresh to saltwater and have about

98 percent success. This is accomplished with gentle handling and an effort to mimic conditions in nature. Better smolting occurs when the fish experience a lower temperature "winter" period, with increasing spring temperatures representing seasonal change. Smoltification is a complex physiological process. If the rearing regime is matched to the natural season, better smolts will result. Size is important, 35 to 40 gram fish are too small to give good smolting results, S_1 smolts should be 50 grams. S_2 are larger.

Q - How does the broodstock diet differ from other diets?

A - Based on an analysis of the nutrient composition of eggs, certain deficiencies were identified. For example, low levels of riboflavin were identified. The vitamin and mineral component of the diet was fortified to compensate for the deficiencies. The protein and fat components were not changed.

Q - How can smolts be distinguished from non-smolting parr?

A - A number of different methods can be used. Traditionally, the level of the ATPase in the gill has been measured. Smolts have elevated levels that remain high for a period in freshwater then, if the fish is not given access to saltwater, decrease again. A more simple method is saltwater challenge. With this technique, the juvenile is exposed to a hypertonic solution of salt. Initially, 30 ppt (g/L) was used to determine smoltification but even parr could live quite awhile in this salinity, so test bath salinity was increased to 38 ppt. Those fish surviving a 96 hour exposure to 38 ppt after direct transfer from freshwater, demonstrate smoltification. Mortality in the test bath indicates parr. Temperature control and recirculation are required for this test. The trials are inexpensive and simple to set up.

Q - How are S_1 and S_2 smolts graded from each other?

A - Size is an important factor. The juveniles must reach 35 g by November of the previous fall if they are to achieve sufficient growth to smolt in the next spring. In juvenile populations, a bimodal distribution of parr size develops. Some physiologists believe the upper mode represents S_1 smolts, the lower mode S_2 smolts. I feel this may not be a sufficiently reliable indicator for production applications. The bimodal characteristic can be overridden in the lab using appropriate temperature regimes, but this is not likely to be possible on ground water that has a constant temperature regime.

Q - If there is poor viability among eggs from broodstock spawned from saltwater, might it be due to the absence of the sharp decrease in temperature that would be seen in freshwater?

A - Putting the broodstock in low temperature water might help increase egg survival, but for practical reasons we haven't done it. Expensive freshwater facilities would be needed, and there would be the concern of transporting disease to the hatchery.

Q - Could you simply rear the broodstock in freshwater pens, rather than putting them out to saltwater?

A - By raising broodstock in freshwater, the natural selection required to have a strong saltwater production stock would be lost. While we generally identify the group of parr from which the broodstock will be selected, final selection is not made until the sixteenth or seventeenth month in sea cages. Substantial natural selection for saltwater suitability occurs by this time and the desirable fish are taken. The genetic specialists tell us that we should not select the biggest fish, but rather take at least 50 males and females from the class just under the maximum size class. This helps to ensure a genetically strong stock.

Q - What happens to the broodstock after egg take?

A - Significant losses occur from handling. We mainly practice hand spawning, but air spawning occurs as well. Some are sold but most are too big for the market. Atlantic salmon can be reconditioned after spawning, but our experience has been that second spawning does not work well.

Q - How long does it take to recondition spawners?

A - Normal fat levels and silvery colour is restored by about July of the next summer.

Q - You talked about resolving problems with initial presentation of feed to emergent fry. What diet improvements have resulted in these improvements?

A - About 6 or 7 years ago we began trying Biodiet feeds, a moist diet, to start the fish and this has been fairly successful. Many producers however, start their fry on dry diets. I have always kept frozen liver bars that can be shredded into the pond. The fry will always eat frozen liver, if nothing else. In the past I have raised fish from swim-up to smolt on nothing but beef liver.

Q - Smolts have been introduced to saltwater in the November following their S_1 spring in freshwater. How does this approach work?

A - Some people call these "fall smolts". In fact, people have tried introducing Atlantic salmon to seawater in just about every month of the year. There are some tricks to these late, fall introductions. First of all, high freshwater temperatures inhibit smolting. It is important that freshwater temperatures fall from summer highs and that freshwater and seawater temperatures be matched at seawater introduction. The fish should be at 100 g. Fall introduction appears to be a viable alternative, but the final economics have not been worked out.

Q - What are the optimum freshwater and seawater temperatures for loading sea pens?

A - Initially, about 1978, smolt introductions were made in mid-May. This was based on natural run timing and temperatures of about 10 to 12 degrees Celsius. As production increased, we were putting smolts out in mid-April and experiencing increased survival. Both the freshwater and seawater temperatures were about 5 degrees Celsius. Seawater temperature must be greater than 4 degrees Celsius to receive smolts. Naturally, Atlantic salmon migrate to the ocean in April and May. This is another example of looking to nature for answers to production problems. It is important to consider the natural cycle of the broodstock and adjust management accordingly. Be sensitive to both temperature and photoperiod.

Q - B.C. seawater temperatures are high, in the 8 to 10 degree Celsius range in April and May. How can the above smolting strategy be applied in our area?

A - Salmon smolt in freshwater, if the freshwater environment is suitable, you will get good smolts.

Q - Do S_1 or S_2 smolts perform the best?

A - There is a long standing argument about the relative importance of age and size among smolting populations. I feel that a 75 g S_1 will smolt as well as a 75 g S_2. S_2 smolts have a number of disadvantages: they experience a higher grilsing rate, are more expensive to produce and offer no advantage in better seawater performance. But there is still disagreement as to the relative importance of size and age in determining the quality of the smolt.

Q - What determines whether an Atlantic salmon juvenile will smolt in the spring and what determines the window of opportunity for sea pen introduction?

A - Increasing temperature narrows the smolting window, or the period between smolting and reverting to parr. At 8 degrees Celsius the window is about four weeks in length. As the temperature rises, the window of opportunity narrows rapidly.

Q - What happens if you miss the smolting period?

A - Try introduction to seawater in the fall, or then the next spring. There may even be possibilities between those two periods.

Q - What is your grilsing rate in New Brunswick?

A - About 10 percent average in New Brunswick. In exceptional cases it may be as high as 20 percent in large S_2 smolts, or as low as 1 percent. We don't "write them off" or even strip them. They are separated into different cages at harvest and allowed to recondition. So even with 10 percent grilse, we don't lose 10 percent of the fish. By next June or July, they are in good shape again. We may lose 5 percent of the grilse. There is little profit in selling small fish, we prefer to market 10 pound fish or larger.

Q - What is the lowest temperature that should occur in the hatchery?

A - Minimum hatchery temperature is 1 degree Celsius. To initiate feeding the temperature should be greater than 12 degrees. For rapid growth, 12 to 16 degree water is required. I think it is impossible to start feeding in the 5 to 8 degree range, 10 degrees is borderline.

Q - At what size can the fry be switched from the heated, 16 degree water to surface water temperature?

A - Surface water temperature should be 13 to 14 degrees before the water source is changed or temperature shock will result in reluctance to accept feed.

Q - Is anyone looking into a 0+ smolt?

A - Yes, the Department of Fisheries and Oceans is working on it.

A 0+ smolt may be accomplished in the laboratory, but not likely in a commercial setting where each of several hundreds of thousands of smolts cannot be supplied with ideal environmental conditions. The freshwater facility for such an operation would be too expensive. I see no practical application.

Q - Are the best Atlantic salmon smolts raised in freshwater net pens?

A - Lake pens are a good system if you have the lakes at an appropriate temperature and the governmental permission. The lake can't freeze over in the winter or get too warm in the summer. In New Brunswick, we don't have appropriate lakes, but this method is used in Scotland and Norway.

Comment: Transfer of fish from freshwater cages to seawater as smolts results in higher sea pen survival. There is less nose rubbing.

Similarities and Differences Between Atlantic and Pacific Salmon

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The similarities between Atlantic salmon and Pacific salmon are that they both live in water, have the same basic parts such as fins and gills and eyes, and both die from neglect. That's about all I can say regarding similarities. Really, they are very hard to compare.

In this talk, I will be comparing mainly chinook and Atlantic salmon. One of the main differences between the two species, is that the chinook salmon die after spawning while the Atlantics may not. The chinooks are killed before stripping, but Atlantics are generally spawned live, using anaesthetic. Atlantic broodstock fish may weigh up to 10 kg. In a large Atlantic it may take up to 5 minutes to expel all the eggs. Chinook salmon typically give copious amounts of milt, while Atlantics tend to give less. The chinook female is at least three years old at spawning, but Atlantics may be grilse, that is mature after one sea winter. Atlantic salmon also repeat spawn, in the wild up to six times.

With regard to egg sizes, we are really talking apples and watermelons. The Atlantic egg is about 0.12 g, while the chinook egg is 0.3 g and larger. Female Atlantics have from 7 to 10 thousand eggs (up to 15 thousand in large females), compared to 4 to 5 thousand in chinook. Atlantic salmon incubation is optimum at 8 degrees Celsius, and water temperatures should never exceed 12. In chinook, 10 degrees Celsius is considered optimum. Atlantic salmon egg fertility is highly variable, from 6 to 82 percent, chinook fertility is reliably higher. Disinfection procedures are the same. Table 1 lists the accumulated temperature units at comparable stages of development.

Table 1. Required accumulated temperature units to achieve comparable stages of development in Atlantic and chinook salmon.

Stage	Atlantic	Chinook
Eyed	330	300
Hatch	500	550
Swim-up	800	900

A variety of incubation systems can be used, including Heath trays, Stieners, and bulk incubators. Heath trays are loaded with 6500 Atlantic salmon eggs and substrate (Biomat) is required for alevins to achieve maximum emergent fry size and to reduce the incidence of restricted yolk sac. About 5000 chinook eggs are placed in a Heath Tray. Substrate increases alevin size and reduces the incidence of yolk consideration. Atlantic salmon eggs tend to fungus more rapidly than chinook eggs. Malachite treatments are applied every 2 days until 2 weeks prior to hatch. Shocking occurs at 300 to 330 accumulated temperature units. The best method to shock the eggs, especially if soft shell is a problem, is through a siphon and into a bucket with a perforated rim. After 24 hours, eggs can be separated with a mechanical egg sorter. After hatch, dead alevins must be removed regularly to avoid fungus infestation. Malachite treatments are stopped 2 weeks prior to hatch.

Swim-up occurs at 95 percent yolk sac absorption among the Atlantic fry. They range from 0.13 to 0.18 g, compared to chinooks

that are from 0.35 to larger than 0.5 g. Biomats from the incubators are placed in the bottom of the ponds and the emergent fry allowed to leave the substrate at will. They must be kept dark.

At ponding, a Pacific salmon looks and acts like a fish. It is up and ready to feed almost immediately. Atlantic salmon emergent fry tend to stay on the bottom of the pond and feed more slowly. Feeding will occur at 8 degrees Celsius, but temperatures of at least 10 degrees Celsius, preferably higher, are required to initiate feeding on a production scale. Chinook will feed in temperatures from 6 to 12 degrees. Newly ponded Atlantics tend to be pushed by current while chinook seem to prefer to swim against a current.

About 50,000 Atlantic fry are ponded in a 2.5 metre tank, in about 6 inches (15 cm) of water. Automatic feeders are essential. The rearing density is 20 to 25 kg/m^2 compared to 35 kg/m^2 with chinook. Worn fins occur if Atlantics are kept at excessively high densities in freshwater, and nipping and eye biting can be a problem. We have started 100,000 Atlantic salmon in a 3.5 metre tank, split at 2 to 3 grams, and reared to a 7 gram smolt at 35 kg/m^3 Atlantics should be reared at 20 to 25 kg/m^3 or higher.

Atlantics are fed small amounts frequently. Atlantics must be coaxed to feed and feed size increased more slowly than might be expected. Chinook feed size can be increased more quickly. Atlantics can be started on a dry diet but semi-moist is preferred for the chinook. We start the Atlantics on Bio-diet or some other semi-moist diet for the first while, then switch to dry. Pacific do better on semi-moist throughout. While chinooks should receive the largest sized pellet as soon as possible, Atlantics must be babied on small sized feed. In our experience, commercially available feed charts recommend higher feeding levels than are necessary (see Table 2). If the temperature drops to 5 degrees Celsius or less, the Atlantic fry will not feed well, but chinooks continue to take feed. Frozen liver bars can be used to encourage reluctant fry to feed, but too much use can lead to bacterial gill disease.

First grading should occur at 0.5 - 1.0 g in Atlantic salmon populations, but chinook do not require grading until 4 to 6 grams. A home-made grader for the tiny fry can be constructed out of knitting needles. Grading early tends to reduce the incidence of pinheads. Atlantic salmon are graded about six times prior to smolting. Tanks should receive fry from incubators that had eggs of similar size so that the frequency of grading is reduced.

Table 2. Atlantic salmon feeding guide (percentage of wet body weight per day.

Degrees Celsius	Wet Body Weight (g)														
	2	5	10	15	20	25	30	35	40	45	50	55	60	65	70
5	2.21	0.96	0.43	0.38	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25
6	2.61	1.20	0.61	0.42	0.35	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
7	3.06	1.44	0.78	0.55	0.41	0.34	0.32	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
8	3.54	1.87	1.11	0.83	0.66	0.56	0.49	0.44	0.40	0.37	0.35	0.34	0.32	0.30	0.30
9	4.01	2.29	1.44	1.11	0.90	0.77	0.68	0.62	0.57	0.53	0.50	0.47	0.44	0.41	0.38
10	4.16	2.64	1.71	1.43	1.19	1.05	0.94	0.87	0.81	0.77	0.73	0.69	0.66	0.62	0.59
11	4.56	2.99	1.98	1.74	1.48	1.32	1.19	1.11	1.05	1.00	0.95	0.91	0.87	0.83	0.80
12	4.59	3.23	2.32	2.01	1.74	1.58	1.44	1.36	1.30	1.24	1.19	1.15	1.11	1.07	1.04
13	4.86	3.46	2.65	2.28	2.00	1.83	1.69	1.61	1.54	1.48	1.43	1.39	1.35	1.31	1.28
14	5.10	3.70	2.90	2.53	2.24	2.06	1.92	1.83	1.76	1.70	1.65	1.61	1.56	1.52	1.48
15	5.24	3.94	3.14	2.77	2.47	2.29	2.14	2.05	1.98	1.92	1.87	1.82	1.77	1.72	1.68
16	5.30	3.97	3.17	2.80	2.50	2.32	2.17	2.08	2.01	1.95	1.89	1.84	1.79	1.75	1.71
17	5.28	3.99	3.20	2.83	2.53	2.35	2.20	2.11	2.04	1.98	1.92	1.87	1.82	1.78	1.74
18	5.17	3.81	3.00	2.63	2.34	2.16	2.02	1.93	1.86	1.80	1.75	1.70	1.65	1.60	1.56
19	4.98	3.62	2.80	2.43	2.15	1.97	1.83	1.75	1.68	1.62	1.57	1.52	1.47	1.42	1.37
20	4.72	3.27	2.46	2.10	1.84	1.73	1.54	1.46	1.39	1.34	1.29	1.25	1.20	1.16	1.12
21	4.41	2.92	2.12	1.76	1.52	1.48	1.24	1.17	1.10	1.05	1.01	0.97	0.93	0.90	0.87

When automatic feeders are used, ratons shown in the chart are to be divided to allow 14 fedings daily at one-hour intervals. When hand feeding, rations shown in the chart are to be divided to allow 7 feedings daily at two hour intervals. For each hand feeding, best results will be obtained when food is slowly presented to each pond of salmon over a 2 to 3 minute period. At temperatures < 5 degrees Celsius, the rations specified for 5^0 C can be used or reduced at the manager's discretion. When temperatures are < 10^0 C or > 20^0, only 1 to 3 meals per day are required.

Bacterial gill disease (BGD) may be a particular problem among Atlantics and seems to afflict larger fry. This may be a result of the passive feeding behaviour of the fry (they are only 2 grams in mid-May when the chinooks are 7 grams), and the culturist's tendency to overfeed. Chloramin-T is used to get rid of the BGD and we try to cut back on the feed.

Another problem among Atlantics is variously called "fin rot" or "fin wear". This can occur with excessive density. Treatment is with formalin and malachite.

Smolting occurs among all chinook salmon after about 3 months in freshwater. Among Atlantics, between 50 and 90 percent will smolt after one freshwater winter (S_1) given the proper temperature and photoperiod regime, the remainder smolt in the following spring (S_2). Unfortunately, in many instances the proper regime is difficult to establish and most are destined to become S_2 smolts. The S_1 smolts of course are more desirable. Early smolting can be encouraged by starting feed in 12 degree Celsius water and increasing to 15 degrees over the summer. The Atlantic parr requires a winter season to smolt properly however, and the temperature should be reduced to 3 degrees for one month, then increased to 8 degrees Celsius to get a good smolt.

Smolting characteristics among Atlantic salmon include faded parr marks, a more slender shape (K_0 0.9 - 1.1), black ends on the fins, a silver sheen, enlarged scales around the vent, a tendency to swim with the current and a successful saltwater challenge test. Fish that have smolted have a brown eye, while the parr eye remains blue. Smolts are sorted from parr by hand. (Note: the use of formalin or malachite within 4 weeks of smolting is not recommended.)

The parr should be vaccinated against furunculosis at 4 g and again at 6 weeks prior to smolting. The S_1 smolt is dip vaccinated, S_2 fish are injected. We injected 20 thousand S_2 smolts and had only 12 mortalities.

The S_1 Atlantic smolts are stocked in ocean pens from April to June, the S_2 smolts earlier in the year. Some work is being done with stocking in November. Chinook can be transported by helicopter, but the larger Atlantics must travel by truck or boat.

Questions and Answers

Q - What size of screen is used in the Heath tray?

A - The trout size screen is required.

Q - How can alevins be incubated in the bulk incubator?

A - Bulk incubators are only used to the eyed stage.

Q - What is the maximum temperature recommended for rearing?

A - Temperatures in excess of 19 or 20 degrees Celsius should not occur in Atlantic salmon rearing.

Freshwater Production Practices at Sea Farm Canada

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There is still much work to be done before we can get consistent production of a high proportion of S_1 smolts on ground water. I will go through a production cycle that we use at Seafarm, but keep in mind that every site is different and every management strategy is different, so there will be differences in what we do compared to what may be desirable at other sites.

Our hatchery facility is under cover. We commence thinning or grading to the 3 m facilities as biomass approaches 1.5 metric tonnes in the hatchery. We have 7.5 degree ground water and use a heat pump to increase temperature. S_1 smolt production would be limited without the heat pump.

We utilize the "combitank" for incubation. The combitank consists of three progressively larger trays that fit into a circular tank. The first tray is sectioned, each section contains a hen's worth of eggs. The eggs are incubated in upwelling flow in this top tray until they hatch. The alevins drop through the screen and incubate in the second upwelling tray. Biomat is introduced at this stage and its use is critical in producing healthy fry. As fry approach swim-up they are dumped into the third tray. This tray is 12 inches (30 cm) deep and utilizes lateral flow. First feeding begins when 10 percent of the fry have absorbed 90 percent of the yolk sac. Water depth begins at 3 inches (7.5 cm) and is raised gradually as fry build in the water column. Being highly territorial, it is critical that feed is presented throughout the tank. Rearing densities are kept to 30 kg/m^2 and transfers are made to the 1.5 m deep tank as this

threshold is approached. We have performed various experiments and have used densities of up to 75 kg/m^2 without long term effects.

Atlantic salmon fry prefer to rest in a slack current, and to dart into a faster current to feed. This can be accomplished in a circular tub with appropriate placement of inlets.

Fry under 10 g convert most efficiently in 16 to 18 degree water, those above 10 g in 15 degrees Celsius. We supersaturate with oxygen throughout the production cycle but exposure to total gas pressure exceeding 100 percent does not occur until October of their first year.

It is important to maintain relatively high densities (12 - 15 kg/m^2 to start) in order that territorial behaviour be dissuaded. Too much space can lead to wandering, unaggressive feed response and even eye pecking. Water depth in the tubs should be increased gradually to maintain optimal densities.

Atlantics reared on 7.5 degree Celsius ground water require several gradings from June to December of their first year. We have moved to a permanently stationed grading facility and away from a mobilized station, where inevitably, ponds were graded out of convenience and not necessity. Counts are integrated with grading schedules as potential smolt status is achieved. The majority of fish from the year class are counted in October and November and, to the greatest degree possible, counted into populations that will be shipped the following spring. Because a smolt is soft and relatively weak, outside of vaccinating in February, populations are left to grow into their final transfer densities.

In the first year of rearing, initial feeding occurred in 7.5 degree water because the heat pump was delayed. Summer temperatures were 9 degrees. Only 30 percent of the stock smolted as S_1.

The following year, fry were started at Port Alice and initial growth was good, but when we were forced to put them into 7.5 degree water the growth fell off. After transport to Dalrymple Hatchery the fry were put on 16 degree water. We got 60 percent S_1 that year. Had the temperature not been reduced at a critical time, higher smolting would probably have been achieved.

Saltwater entry is occurring progressively earlier. In our first year of operation the entry occurred in May and June. Smolts are now put into sea pens in April.

There has been some problem with sexually maturing parr. Early first feeding, and extended growing season and temperature

manipulations contribute to and possibly exacerbate strain specific tendencies to mature early. Our current protocol involves pushing heat to trigger O+ precocious parr in December of their first year. In this way, sexual maturity may be reached and absorption of gonadal tissue completed in time for these individuals to strive for S_1 status.

Ground water smolting facilities must deal with protracted smolting periods. Though late smolts can assist in marketing strategies, they are obviously more expensive to produce. Cost of production is inherently greater for S_2 smolts and higher grilse yields have been experienced. Consequently, production strategies are geared toward the production of S_1 smolts. It will, however, take several more years of experience to consistently predict and produce the appropriate regimes required to assure S_1 potential regardless of stock origin.

Disease in Freshwater Rearing

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Disease has been defined in a number of different ways, sometimes with reference to the invasion of an infectious agent. A broader definition of disease however, may prove to be more useful in fish husbandry. Indeed, any deviation from normal function may be considered to be a diseased condition. This definition includes abnormal function due to an infectious agent such as bacterial, fungal or viral organisms, as well as malfunction arising from environmental challenges, physical injury, nutritional deficiency and various behaviourial stressors. With respect to salmonids, we have not clearly defined many of the risk factors associated with disease outbreaks. I will present an overview of some of the more common problems encountered in the commercial culture of salmon:

Protozoan (Single Cell) Parasites

Costia is a flagellate about the size of a red blood cell, tear drop in shape and tends to attach to the skin and gills of the fish. Costia reproduces by binary fission. Affected fish develop a blue sheen on the skin, which is why it is sometimes called "blue slime disease". There also may be foaming on the water surface.

Hexamita occurs in the gut and clinically may be confused with IPN in young fish. The abdomen is distended, fish may twirl through the water and there are long, trailing, white faecal casts. Furazolidone and sulphonamide are used in treatment.

Tricodina infects the skin and gills. Look for hyperplasia in the gills and copious mucus production. Infections are serious only when numbers are high. In very heavy infections, tricodina may migrate through the anus to the kidney. Formalin is used in treatment.

Mycotic (Fungal) Infections

Saprolegnia occurs on the skin and gills, and in the eggs and alevins in the early life stages. In incubation, the affected individuals must be removed. This freshwater disease appears as a whitish mat over the affected area and is a secondary invader, fixing on dead tissue damaged by some primary trauma. As the disease progresses, the infection will spread over the rest of the body.

Some diseases of young fish appear in different forms at a later life stage. This may be the case with saprolegnia. The fungus can grow through the roof of the mouth and into the brain. Other organs may also be invaded. It is important to remove affected individuals promptly, whether in incubation or rearing, to avoid widespread infection and progressive complications.

Too rapid increase in the pellet size may predispose fish to these infections. Pellets may get stuck and the back of the mouth is traumatized. The damaged area is then vulnerable to fungal invasion.

Myxobacterial Diseases

Columnaris is a freshwater disease typified by "saddle back" necrosis, gill necrosis complex and necrotic stomatitis. Outbreaks may occur at temperatures of 15 degrees Celsius and above, most typically at temperatures over 18 degrees. Fish in hard water that has a high silt load seem to be particularly susceptible. There is sloughing of the epidermis and the exposure of pale skin. Columnaris may occur systemically, but this is uncommon.

Coldwater or Peduncle Disease is seen in incubation when hatch occurs at 2 - 3 degrees Celsius, and is a risk factor below 5 degrees. In rearing, high density and cold water predispose the fish to the ailment. Chloramine-T or oxytetracycline are used in treatment.

Furunculosis is caused by the invasion of Aeromonad salmonicida. There are three subspecies of this bacteria, A. salmonicida salmonicida, A. salmonicida achromogenes, and A. salmonicida nova. Furunculosis is a septicemic disease caused by a gram negative bacteria. The disease is manifest in different patterns:

a) Chronic - lesions on the skin, a less common but very recognizable form of the disease.

b) Acute - redness at the base of the fins, sudden death, the most common form of the disease.

c) Subacute - distended abdomen, excess abdominal fluid, internal haemorrhaging, necrotic spleen.

Muscle degeneration occurs when a clot forms in blood vessels, cutting off the blood supply in a localized area. Necrosis in the spleen is a typical symptom.

Furunculosis is the most important Atlantic salmon disease in terms of its economic impact on the industry. The disease occurs at high temperatures, although the bacteria can survive freezing at -10 degrees Celsius for 50 days.

Prevention is the best strategy against this important disease. In clean operations with careful attention to disinfection, vertical transmission is unlikely. A "carrier state", more probably a subclinical infection, does exist. Vaccines have been used but the efficacy has not been determined with certainty. Treatment is generally with potentiated sulfonamides.

Other diseases have been observed on the east coast but those reviewed above are the most common. Philonema has not been seen. Two cases of enteric redmouth disease have been noted, probably in rainbow trout. In freshwater rearing on the east coast, fungal diseases followed by protozoan and myxobacterial infections are the most important infectious cases of mortality.

Questions and Answers

Q - Is "summer drop-out" in the first seawater summer seen on the east coast?

A - No, most early losses occur very early and are associated with transfer to seawater.

Comment: The "summer drop-out" syndrome may be a result of poor

smoltification that occurs when Atlantic smolts are reared on ground water. The lack of a cold winter may fail to properly trigger smoltification and result in mal-adaption to saltwater. It might be better to transfer in the fall window so that you get a cool down in saltwater.

Saltwater Introduction and East Coast Culture Strategies

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Growing salmon is rather simple if some basic rules are followed. I will outline some of the more important considerations i the husbandry of the Atlantic salmon.

Site selection is the most important decision you have to make. Factors such as water temperature, currents, plankton blooms and so forth are site related and cannot be altered. The potential farmer must ensure that the site selected is appropriate.

Smolt selection is a critical decision. The smolts selected must be true smolts, capable of making the physiological change from fresh to saltwater. Atlantic salmon must be 15 cm or 50 g to smolt, and the temperature and photoperiod regimes should be checked prior to accepting smolts. In New Brunswick, close monitoring of smolt quality has lowered the incidence of disease. Vibrio still occurs, but since it is in the environment, it is difficult to avoid.

Grilsing rates in the stock should be low.

Smolt transport must be quick and gentle. Specifically, the use of dip nets should be avoided. It is preferable that fry not be transported between ponds during the freshwater rearing period. In any case, adequate aeration must be provided during transport of fry and smolts. Pure oxygen may be used, but excessively high oxygen saturation must be avoided.

Net changes occur every four weeks in the Bay of Fundy region in the summer. Fouling can result in reduced oxygen levels within the net. Oxygen saturation below 90 percent can lead to disease and reduced growth among the stock. Every farm should have an oxygen meter so that depressed dissolved oxygen levels can be avoided.

A non-toxic antifouling product is needed in the industry.

Stock density is an elusive factor. Even if the numbers and weight of fish in a pen are reasonably well estimated, they may not distribute themselves evenly in the pen. Generally, most of the stock is found in a 10 to 15 meter band, so the effective density may not be known.

Sampling the stock occurs about seven times in an eighteen month period at the Demonstration Farm and few fish are lost. It has been demonstrated that Atlantic salmon stock can be handled at this frequency without significant loss of fish.

While the Demonstration Farm is run under rigorous rules, the work done on the farm must be considered sea cage trials and not strict experiments. The farm makes a valuable contribution in establishing baseline growth rates, conversion rates and other important production criteria that can be utilized by farmers in management planning.

Farms need a rational business strategy. The first step is to study the market, and then to manage the farm to meet market demand. Another important consideration is the cash flow demand of the farm. Many failures are due to cash flow problems. Planners should consider the cash flow requirements of their operation and bring stock to market so that these requirements are met.

The Demonstration Farm uses a mixture of moist and dry, extruded feeds. Fish are fed to satiation at a frequency that is dependent on their size and life stage. Smolts are fed four times a day, second summer fish three times a day, and broodstock once a day. The best feeding of the day is the last feeding.

One of the feeding trials conducted at the farm compared the final fish weight after 494 days between two groups of fish on different feeding patterns. One group was fed seven days a week, the other six days a week. At the end of the trial, the group fed every day had an average weight of 9.7 pounds, while the group that missed one day's feeding per week weighed slightly more at 9.9 pounds. Trials in Washington State demonstrated that stock on a five day a week feeding regime grew at the same rate as those fed every day.

Divers check the health status of the stock. It is important to dive and observe the behaviour and appearance of the stock. Underwater cameras are providing a convenient means of observing the stock.

Seals were a problem in New Brunswick this winter. One or two

percent of the stock has been lost to seals. Seal scarers and predator nets are used to combat the problem.

Questions and Answers

Q - Do you use anaesthetics during smolt transport?

A - No.

Q - What do you do with the grilse?

A - Grilse are graded from the production pens and put in another pen. They are reconditioned and sold after the next spring.

Q - When are the fish sampled for length and weight?

A - Lower temperature periods are avoided. The stock is sampled in December and then not again until May. Summer temperatures peak at 13 degrees Celsius, so high temperatures are never a problem.

Q - Are the fish graded?

A - Not all farmers grade their fish. Rearing densities are dept to an 18 to 19 kg/m^3 limit.

Q - Do you have a problem with sea lice?

A - No, at least not where the flushing is good. The very low winter temperatures control sea lice well.

Q - Is sex reversal or sex manipulation practised?

A - No, some research is occurring, but there is a tendency for growth to be reduced in the case of sexually altered fish.

Seawater Grow-out Techniques

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Sea Farm Canada Inc. has raised Atlantic salmon in B.C. from 1986 to the present. Several challenges have emerged. Mortalities in the first summer can be high - losses of 10 - 20 percent have not been unusual. Plankton blooms in the fall and spring can be a considerable problem in some locations, both in terms of their immediate impact and in the long term effects of suspended feeding on condition and growth. Furunculosis, along with other bacterial diseases and sea lice infestations, may also be a concern, particularly with a large endemic salmonid population.

While these can be serious problems, they can often be mitigated by close observation of the fish and environmental parameters coupled with flexible husbandry practices and sound decision making at the farm level. For example, during a counting operation the observation was made that fish were particularly skittish and this might be due to conditions of intense light on that day. By waiting until the light conditions were reduced, the stress imposed by the counting procedure was minimized. Timing can be very important.

Critical Periods

A) Seawater Entry and First Summer

Normal smolt seawater entry occurs in the second (S_1) or third (S_2) summer, from April to mid-June. The S_1 smolts are generally 30 to 75 grams, while the S_2 smolts can be considerably larger.

Smolt nets are 1 1/8 and 1 1/4 inch mesh, knotless nylon. Getting the smolts well onto feed can be a special challenge, so the net is shallowed to 2 or 3 metres depth for the first two weeks to achieve a good feeding response and to permit observation. Nets are lowered after the initial period to avoid fouling.

Food is presented soon after transfer, and six to eight times a day in the first weeks. The same size as used at the hatchery is presented to the smolts. A freshwater lens is advantageous at this stage.

Atlantic salmon appear to be more sensitive to feeding practices than other species. When the smolts first arrive on site a palatable, semi-moist feed is used. The food is tossed from one

place, several feet back from the pen, to encourage a conditioned response. The smolts can be skittish, and may establish discrete territories, so care must be taken to cover the full area of the pen surface.

When fish are feeding well, a dry diet can be introduced. When starting a new size or type of feed, the new feed is presented in just one of the several daily feedings. This allows the stock to adjust their feeding behaviour to the new feed type. A meal feed presentation is used, the feed is not "trickled" to the fish throughout the day. The frequency during the first summer is five to six times per day and is reduced to four times per day by early fall. By mid summer the fish should be feeding at 203 percent of their body weight per day. Feed should always be sized to the smaller fish in non-uniform populations to minimize drop out and thinning off problems.

As previously mentioned, first summer mortalities can be very high. In this period, handling, sampling and net changes must be minimized. Mortality should fall to one or two percent per month by early fall.

B) Fall / Winter / Spring

Mortalities tend to be very low over this period. The growers are generally split out to more pens at this time, to reduce densities prior to spring growth. Smolts put in at 45 grams in late spring may well be over one kilogram by mid February. Losses of less than 15 percent are obtainable over the first year, as is a feed conversion ratio of 1.2 if the fish are fed carefully.

C) Grilsing / Second Summer

Grilse are fish that mature after one sea winter. They are predominantly male, but both male and female grilse occur, and they can vary in size from 1 to 3 kilograms. This makes grading by size alone very difficult.

While the percentage of the population that will mature is dependent on the stock, the mode (S_1 or S_2), water temperature, and on the feeding regime, somewhere between 5 and 35 percent will mature. An estimate of the percentage can be made by size sampling in early summer. Grilse tend to have a condition factor of 1.3 or above and as such can be identified in the sample.

Unless the grilse percentage is very low you will probably want to remove them from the general population. They are generally sorted out in July or August depending on the experience of your crew. One or two weeks can make a big difference on accuracy or marketability. Various methods for sorting grilse have

been used but usually it involves moving the fish over a sorting table for visual separation. Grilse tend to be darker in colour, their scale pattern becomes more defined, they produce more slime and they have a rounder, more robust shape.

Size grading of the salmon at this time may be difficult. It has been our experience that growth within the graded populations can be uneven in the months remaining to harvest. The salmon grow quickly over the last summer and fall. The populations that averaged one kg in February will average 2 kg by August and 4 kg by November.

D) Harvesting

Harvesting requirements will vary as to individual company marketing plans. The Atlantics are often in excess of 10 pounds when harvested. This has caused a problem in the use of vacuum type pumps for harvest, as a significant number of fish have been damaged. For this reason the fish are usually brailed.

Questions and Answers

Q - Should you put all salmon in a pen and leave them there until harvest, or should they be split as they grow?

A - The decision usually comes down to economics. Fewer cages are required if fish are split out as biomass increases.

Q - When do you start feeding smolts? On the day of delivery or the next day?

A - The decision depends on the appearance of the fish. If they go deep into the pen and are quiet, then we feed on the day of delivery.

Q - How long are the fish starved prior to handling?

A - They are starved 24 hours prior to diving, 48 to 72 hours for minor handling, and 5 to 7 days for major handling.

Comment: Lake pen rearing assists the smolts' adjustment to sea pen rearing since the container is not different. If the smolts are fed the same feed and pellet size in the sea pen as in freshwater, they generally adjust well to seawater entry.

Q - To what do you attribute the high mortality rate in the first seawater summer?

A - In some areas the visual symptom is a mouth lesion, in other areas this is not a problem. There is a certain percentage of non-smolt drop out, and some myxobacterial infection. Plankton has not been a summer problem to date. Runting and subsequent die-off has also occurred if feed size is pushed too rapidly.

The Nutrition and Feeding of Atlantic Salmon in the Scottish Industry

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I will be addressing the feeding and nutrition of Atlantic salmon, with the experience in Scotland taken as a baseline. Measures of growth, maturation and survival in Scotland will be related to feed in order to consider improvement in those parameters. Much of the data presented is from a survey done by the Department of Aquaculture and Fisheries and from studies completed by various nutritionists.

Freshwater Considerations

Initially, we will consider the production of smolts in Scotland over the last five years. Figure 1 show the number of smolts from 1985 to the present, and an estimate for 1991. Figure 2 show the proportion produced as S_1, which is very high, in the region of 90 percent. The proportion has been increasing slowly.

An important question for feed manufacturers is: how can feed contribute to increasing the proportion of S_1 smolts? It is vital to remember that the juvenile salmon makes its decision to smolt in about October of the same year it started feeding. Work done by John Thorpe (1980) shows that bi-modality in fish size begins at about this time, the large fish will be S_1, the smaller fish S_2.

This size differential has very important implications for feed manufacturers. we want to make the initial feeds the best possible. High fish meal quality is the first important consideration in making a high quality feed. Fish oil quality and method of production must also be examined.

Growth rate is positively related to fish meal quality.

Figure 1. Millions of Atlantic salmon produced in Scotland from 1985 to 1989, with estimates for 1990 and 1991.

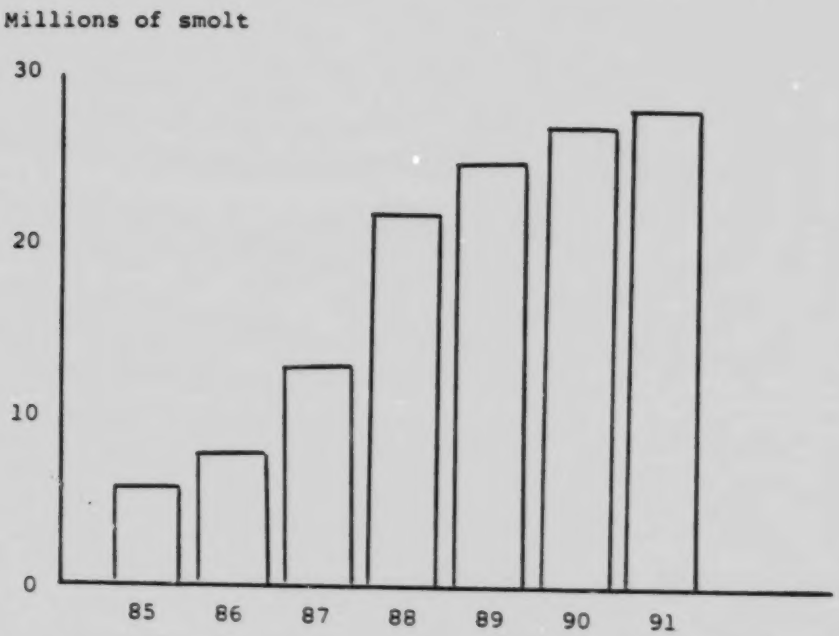

Figure 2. Proportion of Atlantic salmon smolts produced as S_1 in Scotland from 1987 to 1989 with an estimate for 1990.

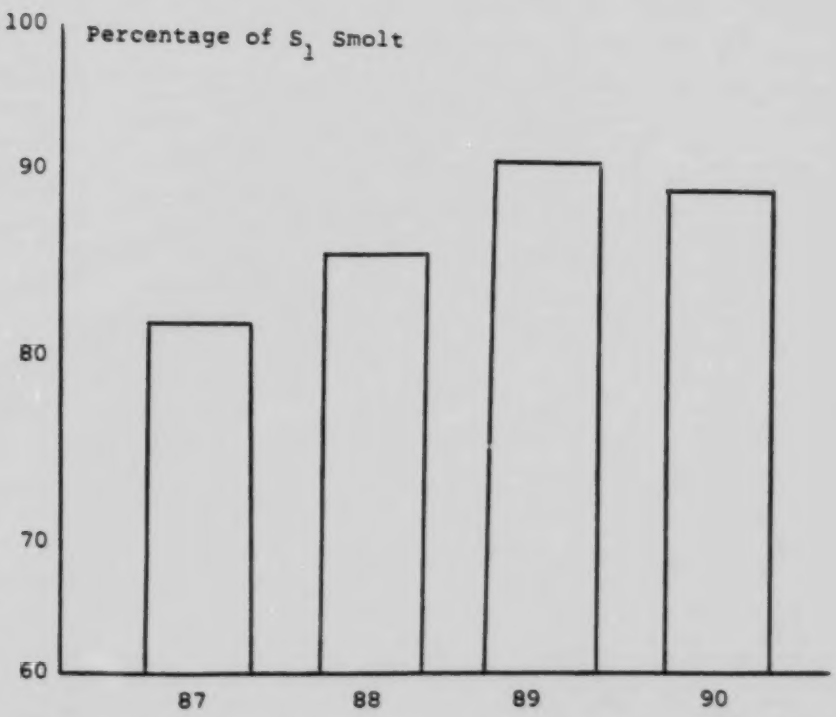

Figure 3 shows the results of an experiment performed to study the effects of feeding with meal made from fresh and not fresh sources, and with fresh meal processed using low temperature methods or the more usual, higher temperature methods. Clearly, the fresh meal produced with low temperature methods yielded the most rapid growth. Similarly, in trials with low temperature meal and standard meal, the low temperature meal produced more rapid growth and therefore, is more likely to produce one year smolts.

Studies have also indicated that extruded feeds produce faster growth (2.4%/day compared to 2.2%/day) and lower food conversions (1.7 compared to 1.4) than pelleted feeds. This may be related to the feeding behaviour of Atlantic salmon. The longer period the feed remains in the water column, the greater chance of the feed being taken. Pellets that sink rapidly may not be taken by the fish.

Fish oil quality affects growth rate if the peroxide value is greater that 5 meq/kg.

Moisture content of the pellet does not affect growth and feed conversion. Feeds with moisture content from zero to 20 percent were fed but no effect on growth rate was observed.

Scottish smolt feeds contain high quality fish meals, high quality fish oils, are "dry" and shelf stable, and extruded and crumbled or agglomerated.

Seawater Considerations

In the sea stage there has been an increase in the number of smolts transferred to the ocean over the past five or six years (Figure 4). Likewise, the number of fish harvested and the tonnage harvested have increased (Figures 5 and 6). Unfortunately, the number of fish and tonnage harvested have not kept pace with the number of smolts transferred. An increasing number of smolts must be transferred to achieve the same level of harvest (Figure 7). Fish are being lost in sea pens. In 1984 there was 15 percent mortality, but in 1989 the loss is estimated at 37 percent of fish transferred. Not only is the level high, but it continues to increase.

Grilse have been decreasing from about 35 to 20 percent of stock. The rate varies with location: Shetland in the north has 19 percent grilse, Strathcyde in the south, 23 percent. West Isles is highest at 44 percent grilsing. Table 1 lists Scottish farming regions from north to south and indicates the rate of grilsing from the 1987 smolt intake.

Figure 3. Atlantic salmon performance on combinations of feed produced from low temperature (LT) and not LT meal, fresh meal and not fresh meal.

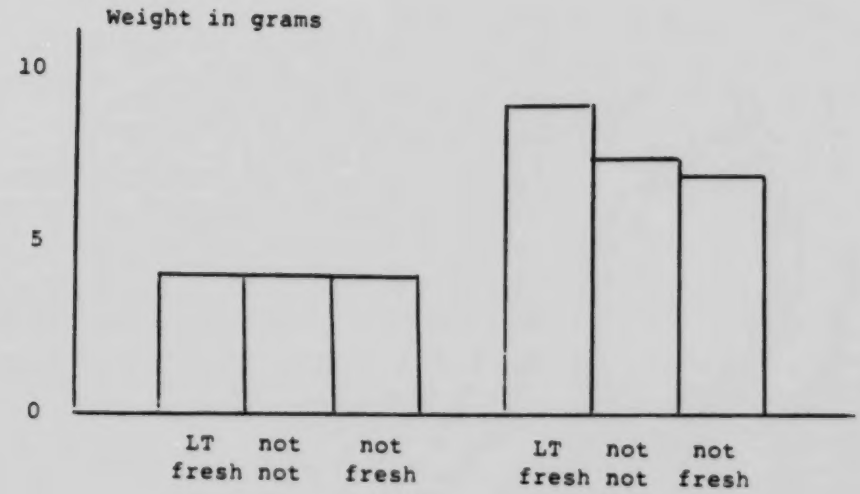

Figure 4. Number of smolts transferred to seawater in Scotland from 1984 to 1989.

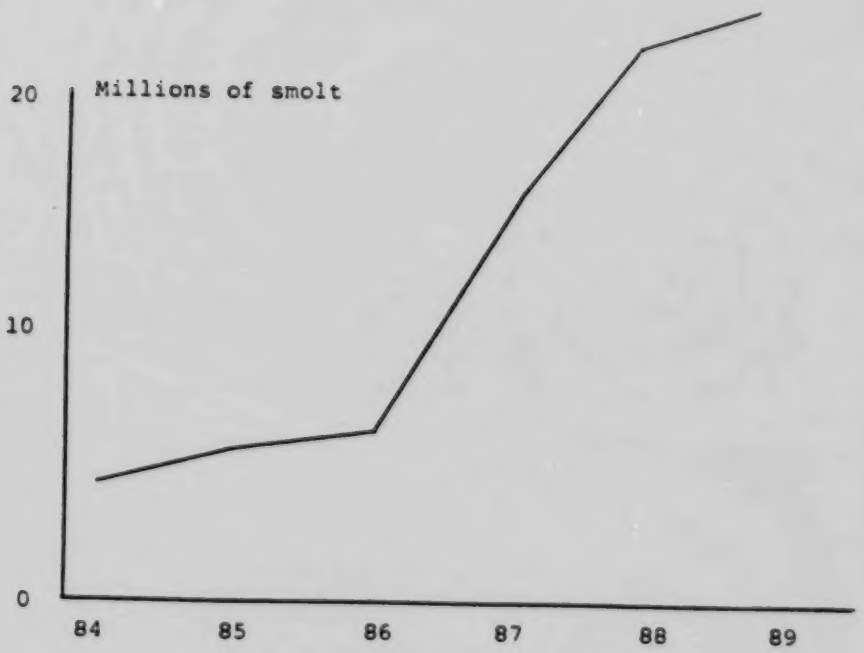

Figure 5. Number of Atlantic salmon harvested from sea pens in Scotland from 1984 to 19[illegible].

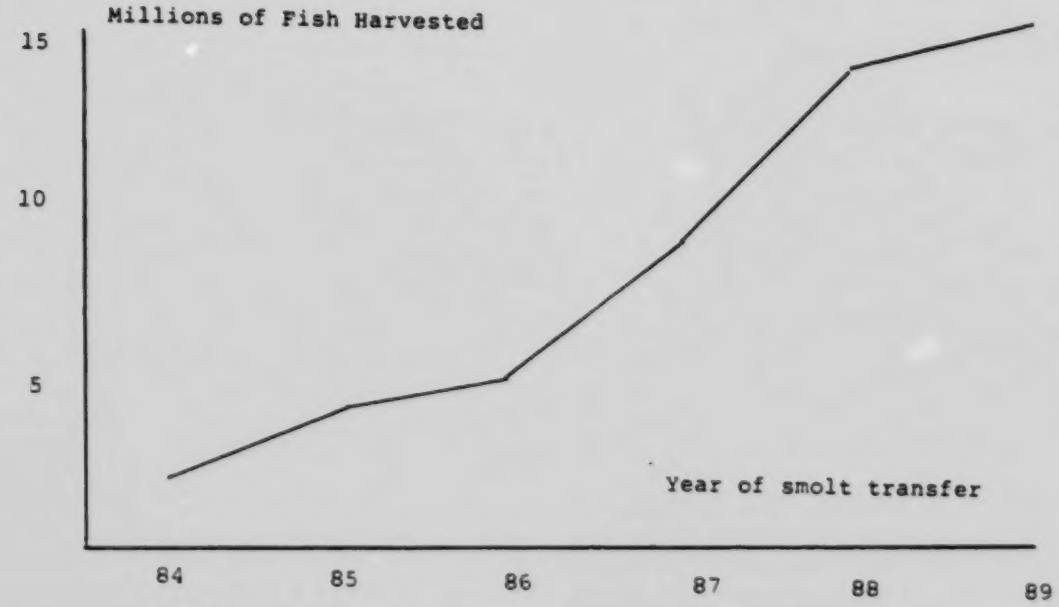

Figure 6. Weight of Atlantic salmon harvested from sea pens in Scotland from 1984 to 1989.

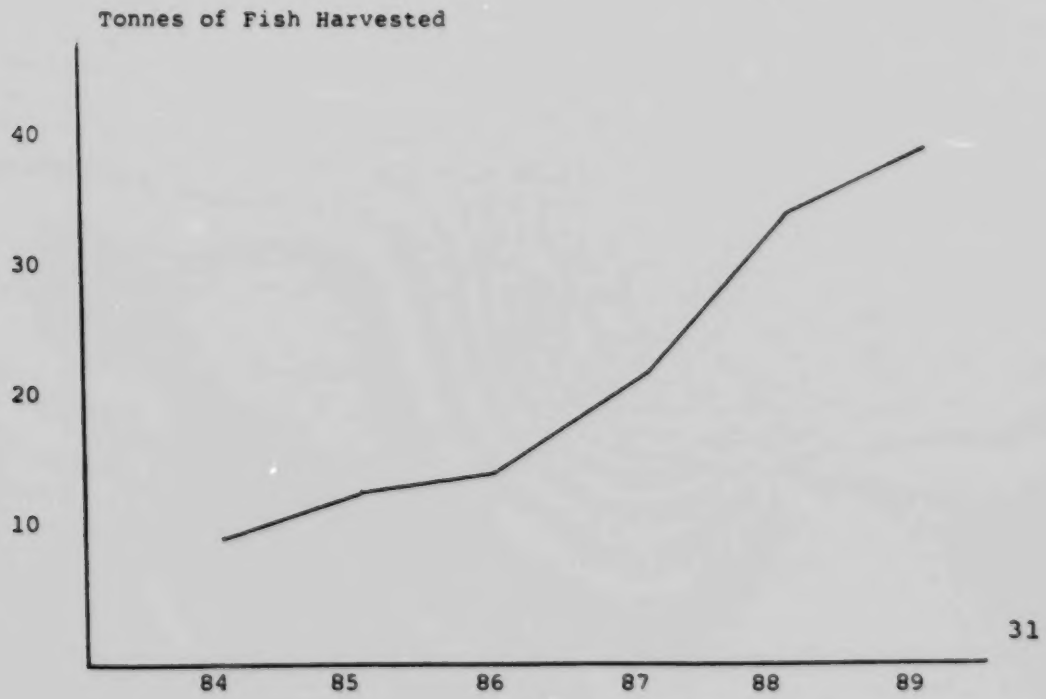

Figure 7. Transferred fish, numbers harvested and weight harvested per smolt year, indexed to 1984 = 100.

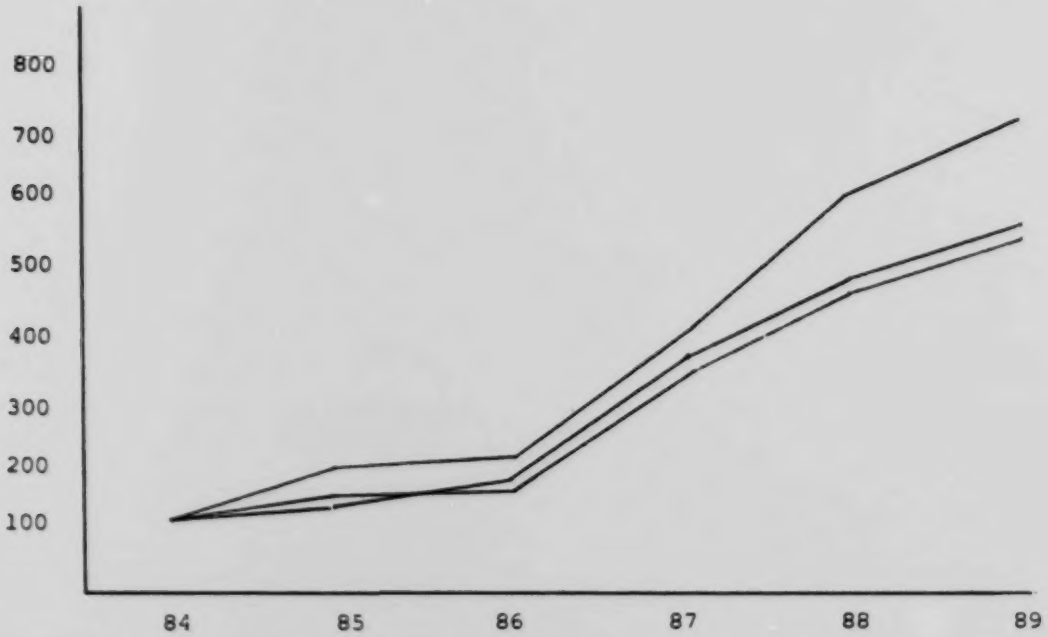

Figure 8. Growth of Atlantic salmon fed extruded or pelleted feed (Norway).

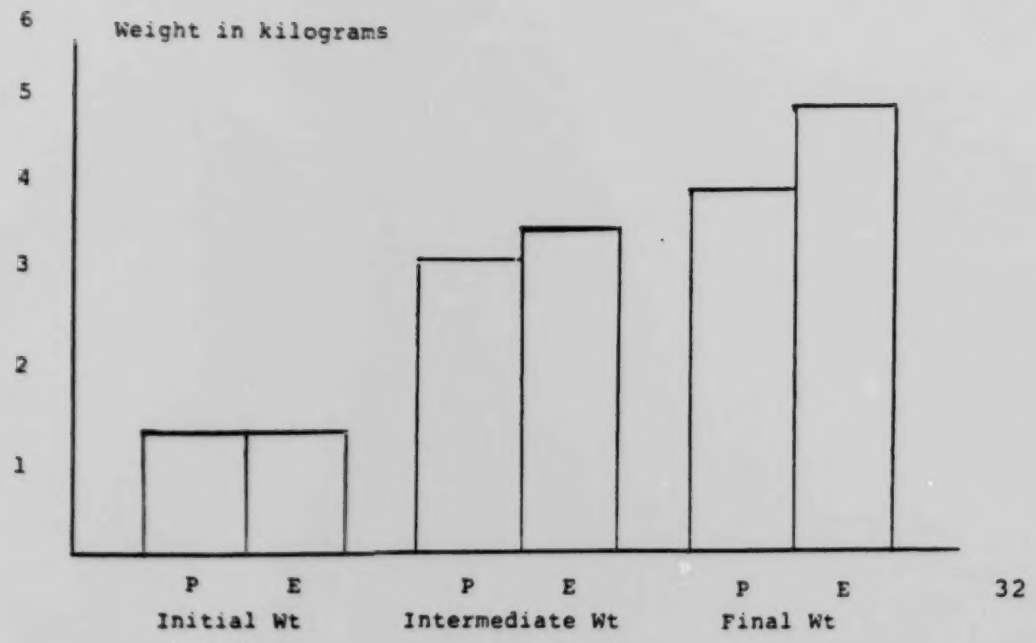

Table 1. Percent grilsing in 1987 smolts according to the sea pen rearing regions in Scotland. Regions are listed from the most northerly to the most southerly.

Shetland	19%
Orkney	35%
West Isles	44%
Highland	26%
Strathclyde	23%

Feed and nutrition is concerned with increasing harvest and recovery (survival) rates, and decreasing the proportion of grilse.

Increasing Harvest Weight

Pelleted and extruded trials show that extruded feed gives better growth and feed conversion than pelleted feed (Table 2).

Table 2. Comparison of growth rate and food conversion ratio in groups of Atlantic salmon fed pelleted and extruded feeds.

	Pelleted	Extruded
Growth Rate	1.58	1.74
FCR	1.01	0.91

Source: EWOS in-house research

Growth rate in Atlantic salmon correlates positively with quality of fish meal. Trials conducted in Norway indicate that where only half the fish meal was from a low temperature source, the growth rate was 0.70 %/day, compared to 0.81 %/day, in feeds manufactured entirely from low temperature fish meal. Doubling time for fish fed a diet containing only half low temperature processed meal was 99 days, but where all low temperature meal was used, the doubling time was reduced to 86 days. FCR for the two meals was 1.18 and 0.98 respectively (Table 3).

Table 3. Comparison of performance between groups of Atlantic salmon fed diets containing only half low temperature processed fish meal, and groups fed diets containing all low temperature processed fish meal.

	1/2 LT Meal	All LT Meal
Growth Rate	0.70 %/d	0.81%/d
Doubling Time	99 d	86 d
FCR	1.18	0.98

Source: EWOS in-house trials

The next area of consideration concerns grilsing rate. Unfortunately, the objectives of rapid growth and low grilising rates conflict. Fish genetically disposed to faster growth also have higher rates of grilsing. Low grilse stocks grow slower than high grilse stocks.

We questioned whether it was possible to achieve a higher growth among a given stock without increasing the proportion of grilse. The question remains unanswered because the data is conflicting. Some studies indicate higher growth within a given stock does not promote higher grilse rate. Others suggest that higher ocean water temperatures decreases grilse rates. Interestingly, salmon from longer, deeper rivers tend to have lower rates of grilsing, perhaps because they must have higher energy reserves in order to successfully swim to the spawning areas (Table 4). Johan Thorpe did some work that indicated high feeding rates did increase grilse rates but did not increase the growth rate. I don't have an explanation for that result. Data from wild stocks in Dempson (1986) suggest that there are "... no consistent significant differences in growth rates of grilse and 2 sea winter salmon within a smolt class..." . Norwegian data (Naevdal et al, 1977 and 1981) indicate that there is no difference in weight between mature and immature fish before those fish become mature. Scottish wild stock data clearly show that high water temperatures decrease the number of grilse. Water temperature has high predictive value in estimating the number of grilse returning.

The conclusion is that there should be no expectation of controlling grilsing rate by feed type or feeding.

Table 4. Relationship (additional % variance explained by each variable) between grilsing rate in Atlantic salmon stocks and the environmental variables of ocean temperature, length of river, discharge of river and latitude.

	Male	Females
Ocean Temperature	34%	43%
Length of River	21%	24%
River Discharge	6%	3%
Latitude	2%	2%

With respect to disease control, there is conflicting evidence on the effect of vitamin C on the immune response. Vitamin E may suppress the immune response. Feed and nutrition may not solve disease problems.

In summary, feed can be expected to help increase the S_1 percentage, grow fish faster, more efficiently with extruded, high fat, LT meal based feeds, but don't expect feeds to solve grilsing or disease problems.

Questions and Answers

Q - Can you briefly explain where we are with respect to differences in fish oil levels between Atlantic and Pacific salmon diets?

A - In Norway, feeds are being produced that are 24 percent fat or higher, in Scotland 22 percent. Another pelleted feed has 15 percent fat.

Q - Do you feel that grilsing is more related to genetics, or to feed and environment?

A - I feel that the determination is predominantly genetic, and that feed or husbandry may or may not have a role.

Q - Do you feel that salt should be put in the smolt diet prior to saltwater transfer?

A - Pre-transfer diets with elevated salt level can increase osmoregulatory capability in rainbow trout. The transfer diet is

fed six weeks prior to transfer. Rather than salt, Finnstim, a more palatable natural osmolyte, is used in pre-transfer diets.. It is also used for a short period of time in post-transfer diets. We will be doing work with chinook and coho to determine if Finnstim does in fact increase the osmoregulatory status in these species.

Q - Why should the mortality increase over the last several years?

A - Furunculosis, pancreas disease and sea lice are the primary causes of mortality. Pancreas disease is almost certainly a viral disease.

Q - Why are the diseases becoming more prevalent?

A - The first instance of pancreas disease at a site seems to occur randomly, but once the site is affected, pancreas disease occurs every year.

Comment: When accountants and bank managers start managing farms, disease tends to increase. On the other hand, after several years, a site may simply need a rest.

Q - How did the feeding rates compare in the extruded and pellet trials?

A - The feeding rates can be calculated from the growth rate and food conversion. If the growth rate is lower and the conversion rate higher, it follows mathematically that the feeding rate was lower. The reason for lower feeding rate with extruded feed is that this feed contains more energy than the pelleted diet, and fish automatically eat less.

Q - What is your feeling between controlled feeding and satiation feeding?

A - You definitely need more control over feeding - studies of how fast the fish are growing and how the fish are utilizing the feed. In Scotland there is a tendency to meal feeding, rather than feeding small amounts frequently.

Q - What does "low temperature meal" mean?

A - Low temperature meal is produced under vacuum drying, at less than 100 degrees Celsius.

Management of Sea Lice

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Our approach to research in the Irish fish farming industry has been to trouble shoot and provide practical solutions to industry problems. We have not concentrated on questions of basic science. We operate two groups, a diagnostic group and a research group. The research group works on the problems identified by the diagnostics group.

Our industry started in 1976, but there was no mention of sea lice prior to 1983. The summer of 1983 was very hot. There were about two months without a cloud. Temperatures in surface waters were consistently over 20 degrees Celsius for 6 weeks. The salmon were not well. A disease occurred that we called "summer lesion disease" that did not respond to treatment. We suspected the primary cause was lice, and the lesions developed afterward.

In 1983, we advised our farms that rigorous lice control would be implemented. The recommended treatment was Nuvan. If lice numbers on the smolts exceeded 7 or 8, treatment was to be implemented. Certainly if the numbers reached 18 per fish, they should be treated.

Unfortunately, operating procedures changed to avoid summer lesion syndrome and the farms moved offshore and into very large cages (10,000 m^3, 200 tonnes per cage). It was impractical to administer a 1 ppm Nuvan treatment in a cage of that size. Since we could not treat for lice, an alterative therapy was sought.

There are other problems with Nuvan. The first is the concern with drug toxicity to workers. It is a potent neurotoxin, can be taken up by skin contact and is sold as a 50 percent solution. Many of the farm workers refused to use protective clothing and there were repeated cases of worker poisoning. There is also a concern with toxicity to fish. Fish treated with Nuvan take a long time to recover, and recovery is longer after each treatment. Some fish that have been repeatedly treated are more or less comatose.

The standard method of administration is to lift the cage,

line it with a tarpaulin and add the Nuvan. The procedure itself is stressful to the fish.

There is clear evidence that pancreas disease is grossly exacerbated if anything goes wrong with the treatment. Also, handling the fish, particularly in the first summer, increases grilsing rates. Nuvan adminstration is very labour intensive, costing 3/4 million dollars to administer the treatment. Cross infection from untreated cages was a problem.

The potential for environmental damage from Nuvan is clearly established, although actual cases have not been reported. Public perception of Nuvan treatment is very poor. There is a legal problem since licensing for treatment is inadequate.

Suggested Alternatives to Nuvan Treatment

1. Alternative bath (chemicals, basically rejected by the industry)

2. Oral administration (our choice)

3. Vaccination (funded by several European countries, some preliminary positive results)

4. Biological control (use of fish rass to eat the lice, problem with supply of rass, and predation on salmon if lice numbers are low)

We chose to select an oral administration. We did not have the resources to try many drugs, so selected a single likely candidate called Ivermectin. The half life of Ivermectin in water and light is less than 12 hours, in thin films 4 to 6 hours, in aerobic soil 20 to 47 days, in anaerobic soil significantly longer. Bio-accumulation does not occur with the drug. Table 1 lists the $LC_{50}96$ for several representative marine species.

Note the very high LC_{50} for the commercial species Eastern oyster and Blue Crab. The treatments that we are using may not be reaching the levels toxic to rainbow trout, which are very low, so most other species are not likely to be affected.

We have published some of our early data in the European Bulletin of Fish Pathologists. We have shown effective control of lice numbers. We can maintain fish for the whole of their sea life with less than three lice in situations where control fish had 200 lice per fish. We have done this over three years and have clear

Table 1. The $LC_{50}96$ exposure in ppm for various species:

Daphnia	0.34 (48 hours)
Mysid Shrimp	0.022
Eastern Oyster	430
Blue crab	153
Bluegill sunfish	9.6
Sheepshean	15
Channel catfish	24
Carp	42
Rainbow Trout	3.2

evidence of effective therapy. We have tried for a long time to limit knowledge of results because we did not want widespread use of the drug before we had information about environmental impact.

In a case of very high (200/fish) infestation, a treatment was administered that was 4 times as strong as the normal treatments and the fish recovered completely. We also fed this to broodstock fish with no ill effects on reproduction. There is no long term toxicity. There is no significant difference in weight gain between Ivermectin treated fish and the controls.

In another experiment we were interested to see if Ivermectin would affect the incidence of pancreas disease relative to Nuvan treatments. In this single experiment, pancreas disease was delayed in onset and reduced in severity in the Ivermectin treated groups. We have added a little bit to the published data on LC_{50}, particularly with respect to the larval stages of the commercial shellfish species. LC_{50} for these species are in the range of 100 ppb or higher. Most of them are 100 times less sensitive than rainbow trout.

If there are to be problems, they may be in the sediments underneath the cages. We are looking into this concern.

It appears that we have a good alternative to Nuvan. The strategy we are recommending is to use the Ivermectin from saltwater transfer through to October, since the first seawater summer is the most critical time for sea lice infestation. The long term future depends entirely on licensing. Extensive ecotoxilogical studies are being done. Licensing may occur by early 1993.

Questions and Answers

Q - What is the therapy procedure?

A - I expected that we would be responding to infestation. Companies are currently treating 2 days per week during the summer.

Q - Have you information on tissue residues?

A - We have difficulty finding a lab that can detect the drug at the levels that we are interested in. We have found a European government lab that can test to 2 ppb and have started looking at tissue residues. Tissue withdrawals will probably be 200 to 300 degree days.

Q - Does the drug put the fish off feed?

A - No

Q - Do we know what kind of site conditions foster sea lice?

A - Large, old sites have the problem. We don't have enough variation to determine environmental conditions.

Q - Have you looked at other parasites?

A - No

Q - Does it affect all species of sea lice?

A - Both species of sea lice that affect the Irish industry.

Q - Would micro-encapsulation offer any advantages?

A - We are presently using a preparation which is for sheep and mixing it on the farm in fish oil. The drug will be incorporated into the feed.

Q - If certification is made, who will control the distribution of the drug?

A - We have no control over the drug, nor does the company involved in experimentation.

Q - What dosage are you using?

A - At the moment, 0.05 mg/kg feed. That may not be the lowest level that will be effective.

Q - Are all life stages equally affected by the drug?

A - We don't really know because of the way we use the drug.

Q - Have you tried seeing if the treatment works at different stages of the life cycle of the lice?

A - No we haven't.

Q - What do you believe the cost of the drug will be?

A - I don't know, but the industry is very hungry. I believe all the drugs used in the industry will be getting expensive.

Q - Does the Ivermectin kill the lice or cause drop off?

A - I don't know, we treat and the lice disappears. We are able to treat the whole population of fish at once so we believe we are reducing the challenge.

Q - Have you tried treating from smolt transfer for a couple of months then stopping?

A - We have done that sort of thing when testing for drug withdrawal times. Our experience there is that we have roughly 20 days protection. With Nuvan, re-infection is rapid. With Ivermectin, the fish become resistant, not just the water.

Q - Could Ivermectin be used to control on an intermittent basis, such as when lice was observed on the salmon?

A - It takes two weeks to build up control. We don't want to use intermittent treatments because there may not be fast enough response to heavy challenges.

Q - Since the lice problem did not occur until several years after the industry became established in Ireland, would it be a reasonable strategy for B.C. farmers to look for additional sites so that they could move if lice numbers increased after a period of time?

A - Some farms are trying site rotation. That is what we tried to do by moving the sites off shore. It didn't work. Moving the large oceanic sites is very difficult and really not an option.

Diseases of Atlantic Salmon Reared in Net-pens in the Pacific Northwest

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The following are descriptions of diseases that I have observed in net pen reared salmon in Washington State, USA and British Columbia in recent years. With the growth of culture of Atlantic salmon in the Pacific Northwest, several new diseases have been observed in this species. In addition, some diseases that are well recognized problems in Pacific salmon have been detected, as well as some problems previously described in Atlantic salmon in Europe. Noxious phytoplankton (e.g. Chaetoceros and Heterosigma) are not covered in this discussion because they are dealt with in another presentation (see Ed Black's discussion).

Disease of Undetermined Causes

Netpen Liver Disease (Toxicopathic Liver Disease). This disease was first observed in pen reared Atlantic salmon in Port Townsend Bay, Washington State, in the summer and fall of 1986. The disease has recurred every summer since it was observed, and has now been detected at several sites that rear Atlantic salmon in B.C. In Port Townsend, the disease has repeatedly caused 60-90% mortality in smolts. The disease does not appear to be as severe in B.C.

Affected fish are lethargic but do not exhibit any external lesions. Dissection reveals a shrunken, yellow liver in many of the affected fish, while the other organs appear normal. Histological examination reveals severe degeneration and megalocytosis in the liver parenchyma. Megalocytosis is caused by failure of cell division during mitosis, resulting in polyploid nuclei. This lesion is caused by a number of toxicants, including

man-made chemicals, and toxins from plants and fungi. When fish are moved to clean water, the liver regenerates, but megalocytic cells will persist for several months.

The cause of net pen liver disease is unknown, but experimental evidence indicates that it is caused by a water-borne toxin. The toxin is probably not related to feed contamination because fish fed diets from the same lot but maintained at a different site showed no signs of the disease. It is unlikely that the agent is a man-made toxicant because the disease has occurred at apparently pristine sites in British Columbia. Net pen liver disease, and presumably the toxins, are prevalent in the summer and diminish in the winter months. This suggests that perhaps an alga is producing the toxin. Presently a specific alga is not implicated. In collaboration with Drs. Raymond Anderson and Max Taylor, University of British Columbia, we are looking at potential algal toxins and trying to identify a specific alga using bioassays and field examinations.

Pancreas Syndrome. Pancreas syndrome (a different disease from Infectious Pancreatic Necrosis caused by the IPN virus) is an important problem in pen-reared Atlantics in Scotland. We have detected the disease at one site in Washington State. Some researchers have suggested that it is caused by a vitamin E/selenium deficiency whereas experiments by others suggest an infectious etiology. The disease begins at approximately 8-12 weeks after seawater introduction. Affected fish are extremely emaciated and lethargic. Dissection may reveal haemorrhages around the pyloric caeca and pancreas. Mortality is variable and chronic, and may reach 10-20%.

Bacterial Diseases

Cytophaga-Flexibacter. Skin and mouth lesions caused by Cytophaga-Flexibacter sp., commonly called "myxobacteria", are common on Atlantic salmon during their first spring or summer in seawater. A ctyophaga sp. infection that causes skin lesions occurs about 1-3 weeks after introduction, and is probably associated with skin abrasions that are inflicted during transport. Severely affected fish show large ulcers with exposure of the underlying muscle. Unlike some myxobacterial diseases of fish in freshwater, we have seen no systemic involvement and the internal organs appear normal. Affected fish show high plasma sodium levels, indicating an osmotic imbalance.

Another myxobacteria species is associated with mouth lesions, particularly during the summer months. The initiating cause of the lesion is unknown, and some have suggested that the infection occurs when the mouth is abraded by eating crab larvae or biting nets. An essentially identical disease has recently been observed

in cod from estuaries of the North Sea. This mouth infection has caused serious problems at some farms in B.C. and Washington.

Furunculosis. This disease, caused by Aeromonas salmonicida, is a well recognized problem of salmonid fish reared in freshwater, and has caused epizootics at several seawater sites. Apparently healthy fish with subclinical infections can develop the disease after they are transferred to seawater. Furthermore, furunculosis can apparently be transmitted in seawater. Antibiotics, such as Romet and oxytetracycline, are used to treat infections, and success is variable. We have encountered several strains of A. salmonicida that are apparently resistant to these antibiotics. Oxolinic acid has been used successfully in some cases. Vaccines are available for the disease, but their efficacy is questionable because high losses due to furunculosis have occurred in fish that have been vaccinated.

Bacterial Kidney Disease. Whereas bacterial kidney disease (BKD), caused by Renibacterium salmoninarum, is probably the most important disease of pen-reared chinook salmon in B.C., it appears to be less of a problem in Atlantic salmon. The disease in both species is similar, except Atlantic salmon appear to mount a more effective granulomatous tissue reaction to the bacteria. Recently, some fish farmers have reported increased losses to BKD in Atlantic salmon in B.C., so in the future this disease may also become an important problem in this species.

Parasites

Kudoa thyrsitis. This myxosporean parasite commonly infects the muscle of hake in B.C. It was first observed in Atlantic salmon net pens in Washington State, where it was associated with mortality. We have recently detected the parasite in market fish from a few farms in B.C. and Washington. Although the parasite was not associated with any apparent morbidity, heavily infected fillets that were smoked were soft and showed white patches in the flesh. Therefore, the parasite apparently is not important as a disease agent, but heavy infections may affect the marketability of the smoked product.

Sea Lice. Sea lice, Lepeophtherius salmonis and Caligus cleminsi, have been observed at several sites, but only in a few cases have infections been as severe as reported in Europe. In Europe, netpen sites that have been in operation for several years generally have more severe problems than those which have been recently established. Based on these observations, sea lice may become a more serious problem in the near future. Infections are often controlled by external treatments with organophosphates such as Nuvan or Neguvon, but these chemicals are dangerous to fish farm personnel and the environment. Recently, oral treatments with

Ivermectin appear promising (see Dr. Peter Smith's presentation).

In conclusion, the culture of Atlantic salmon in the Pacific Northwest appears promising, and this fish appears to be more resistant to certain diseases (e.g. BKD) when compared to chinook salmon. However, merely switching from chinooks to Atlantics will not eliminate all the disease problems encountered in net pen aquaculture. Diseases should be minimized by various methods, including good husbandry practices, selection of an appropriate culture condition (site selection), use of uninfected stock, use of nutritionally sound diets, prompt and accurate disease diagnosis, and properly applied treatments or control measures.

The Impact of Harmful Phytoplankton on Atlantic Salmon

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The problem of serious plankton blooms is ubiquitous throughout the world for many species of fish. Table 1 lists the historical losses in salmon farming due to plankton blooms. Blooms may occur on the surface of the ocean or at depth. Heterosigma blooms are often solid with a distinct edge that is clearly seen from the air. Other blooms may be patchy or stringy.

Table 1. Historical losses of farmed salmon to plankton blooms in the B.C. aquaculture industry.

Year	%of Industry	Value of Lost Production	Principal Species
1986	38%	$2.5 M	Heterosigma
1987	19%	$3.9 M	Chaetocerous
1988	<1%	$0.5 M	No major bloom
1989	5%	$4.2 M	Heterosigma

Heavy mortality may occur at farm sites in very short periods of time or at very low concentration of plankton. Atlantic salmon mortality has occurred in as little as fifteen minutes after towing

into a bloom. Chaetoceros convolutus concentrations of 2 or 3 thousand cells per litre can kill salmon, Atlantics seem to be more sensitive. Death starts with large fish and mortality is dose related an cumulative. Repeated exposure to Chetocerous will be characterized by increasing susceptibility to low concentrations. If fish survive they will recover and regenerate damaged gill tissue. Secondary Vibrio infections are common.

Mortality due to algal blooms is caused by oxygen starvation, high total gas pressure, abrasion of gill tissue and toxins. In marine waters the first two of these mechanisms rarely occur.

Management strategies include proper siting, farm design, careful monitoring and mitigation. Multiple intakes are utilized for land-based farms. Raising and lowering cages has been suggested. Easily detachable mooring will assist in rapid removal of the farm to another site. Operators must be aware however, of the danger of towing into a bloom during the move.

Other mitigation techniques include pre-emptive harvest, reduction of metabolic oxygen demand by cessation of feeding, shielding stock with non-porous barriers, bubble curtains and the injection of clean water.

Prediction of the duration of the bloom is an important consideration in assessing the risk to the stocks, deciding whether to immediately harvest the fish, or even whether to resume feeding. It is not possible to generalize what leads to the termination of a bloom, though for flagellated phytoplankton water column stratification may be important. The Heterosigma akashiwo bloom in Sechelt ended with a return of mixing in the water column.

Deep nets will allow fish to avoid the plankton by sounding. This is demonstrated by the data in Table 2.

Fish will avoid the bloom if allowed the proper pen depth. Cages have been designed that will permit the entire cage to be lowered below the bloom.

Towing is one of the favoured means of dealing with blooms in Japan. Because of the large mass of the pens however, currents and wind can cast the pen system and boat off course. Towing into a bloom is also a risk. Towing should occur prior to the bloom arriving on site and before gills are damaged, which could make the fish more susceptible to the stress of movement. The front of the cages may collapse during movement and result in very high densities in the pen or press webbing against the fish. Cages can be designed to facilitate movement.

Table 2. Percent losses relative to depth of net.

10 m Depth	12 m Depth
64	2.1
21	2.4
19	3.9
35	2.2
40	1.9
38	1.1
36 % Mean	2.3 % Mean

The Heterosigma akashiwo bloom that occurred last year (Table 3), exposed about 50 farms with a total of 5000 tonnes of production. Only 2 farms lost over 30 percent of the stock. About 600 or 700 tonnes of fish were lost. In comparison, in Washington state, 5 farms were exposed to the bloom, 3 sustained heavy losses, about 1200 tonnes were in the water and about 800 tonnes were lost. The heavy losses in Washington were due to raising the more susceptible Atlantic salmon and to plankton mixing throughout the water column. The point is that if you raise Atlantic salmon you must understand local currents and mixing of the water column and mitigating techniques must be in place to deal with a bloom if is occurs.

Table 3. Effects of the major 1989 Pacific coast plankton bloom on the Canadian and U.S. salmon farming industries.

Exposed Industry	Canadian	U.S.
# of sites	50	5
tonnes	5000	1200
Impacts on Industry		
sites with >30% mortality	2	3
tonnes lost	600	800

THE ATLANTIC SALMON WORKSHOP

Questions and Answers

Q - Is Atlantic salmon more susceptible to Chaetoceros or just Heterosigma?

A - Atlantic salmon is more susceptible than Pacific salmon to both types of bloom.

Q - What is the lethal level in Atlantic salmon for Chaetoceros?

A - For chinooks the lethal level is about 3000 cells per litre, for Atlantics it may be as low as 1000 cells per litre. The boundary is not well defined. Different species of Chetocerous are damaging at different concentrations. The development of secondary spines on the plankton is important to the effect on the fish.

Q - Atlantic salmon have survived in Chaetocerous levels of 20,000 cells per litre at our farm?

A - Differences in the effect of the plankton at different concentrations may have to do with the development of secondary spines.

Q - Why are some species more susceptible?

A - Gill structure has been implicated. Sockeye salmon are thought to be especially sensitive due to the fine gill structure.

Q - In chinook salmon, the mature female is more susceptible to Chaetorceros than the silver fish. Is this the same in Atlantics?

A - We don't have that information.

Comment: That was our experience last year. The Atlantic broodstock was wiped out. The plankton effect starts with the largest fish, and progresses to the smaller fish.

Production Cost and Return Considerations in Atlantic Versus Pacific Salmon

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Don't let Atlantic salmon become a gold rush. The cost of production of the Atlantic salmon is about the same as for chinook. The market value is presently higher for Atlantic because they are produced at a slightly higher weight, if that weight range is flooded with product, the market value of the 3 kg+ fish will be reduced.

The Need to Monitor the Cost of Production - Dr. John Spence

Land farmers use cost of production as a basic parameter for monitoring the progress of their business. For the first few years of salmon farming in B.C., it was very difficult to determine the actual cost of production for the product. Many business plans proceeded with little or no good information of cost of production. I feel that one of the reasons we have had so many receiverships in the industry, is that there was a lot of naive money put into the industry without anyone taking a hard look at the cost of production and the money that could be received for the product in the market place.

Cost of production in salmon farming is very variable, depending upon many biological and environmental factors. It is an objective measure of the competitiveness of our industry. It enables us to compare ourselves with other producers in the international market. As we meet today, the U.S. Department of Commerce is meeting in Boston to consider a 27 percent tariff on Norwegian salmon because of alleged dumping practices. Some of the main evidence before the commission relates to the cost of production in Norway and elsewhere. A report made by the Scottish salmon farmers was produced with the intent of putting a tariff on Norwegian salmon coming into the EEC.

Cost of production is a good guide to research and development

priorities. Research has not always been well articulated with the needs of the industry. If research does not directly contribute to reducing to cost of production, it is difficult to justify. Finally, financial institutions need proper analysis of cost of production data so that the risks and profit potential of investment can be assessed. Survey data covering the whole industry over a period of time is needed to give confidence to the investment community if they are to finance this industry.

Briefly going through the production cycle, I will give an overview of the cost of production. First of all, at the smolt stage the cost components typically are (Table 1):

Table 1. Typical smolt production component in the cost of production.

Variable Cost eggs, feed, wages, vaccination	0.75
Depreciation, interest	0.55
	1.77 +/- 50%

There is considerable variation in the cost of production for smolts throughout the world, depending on the growth rate, mortalities, size of hatchery and its cost, ect.

Early losses in smolt production do not affect the cost of production markedly. Unexpected losses due to poor management can lead to a doubling of the cost of production for smolts.

The key factor in reducing the overall cost of production of salmon in the sea is not having an inexpensive smolt, but rather a high quality smolt - fast growing, properly smolted, good fins, vaccinated and the right genetic background. Thus, the top grading factors that can reduce the cost of production of smolts include the efficient utilization of the fixed investment by using techniques such as oxygenation and net pen rearing of surplus smolts.

Sea Rearing

The cost structure with Atlantics is not very different from that of chinook (Table 2):

Table 2. B.C. chinook sea pen cost of production per kilogram.

Variable Costs	$ Can.	%
smolt	0.62	9
food	2.75	40
processing	1.25	18
stock insurance	0.16	2
interest	0.30	4
selling	0.87	12
	5.95	
Fixed Costs:	1.08	15
Total Cost	7.03	

The major cost components are the variable costs. Improving feed conversion or reducing the mortality will have a dramatic effect on the bottom line total costs.

It must be remembered that the overall cost of production per kilogram is reduced as fish get bigger. Catastrophes such as algal blooms and other major mortality events however, can immediately reverse the cost of production on a farm and put the company into an unprofitable situation. The farmer must therefore monitor cost of production on a regular basis and be prepared to take remedial action to overcome unexpected events.

The major input costs for Atlantic salmon production are given in Table 3.

Table 3. Breakdown of cost of production for Atlantic salmon.

	Percent of Total Cost
Feed	50 - 60 %
Smolt	10 - 12 %
Depreciation	10 - 15 %
Insurance	5 - 8 %
Labour	5 - 10 %
Overhead	3 - 5 %
Veterinary	1 - 2 %

In recent sensitivity analyses of the Cost of Production in B.C., the most sensitive cost variables were ranked in descending order of significance as in Table 4.

Table 4. The most sensitive cost variables for sea pen production of salmon in B.C.

Item	Type
Growth rate	Biological
Price of feed	Economic & Biological
Food Conversion Ratio	Biological
Mortality Rate	Biological
Cost of Processing	Economic
Offal Loss	Biological
Smolt Price	Biological
Insurance	Economic
Capital Investment	Economic
Labour	Economic
Administration	Economic

Growth rate is the largest single variable in the cost of production. Small gains in growth rate can lead to substantial increases in the profitability of the company. Price of feed is a major factor because so much of the cost is in the feed and the food conversion ratio likewise, has a major impact on profitability because of the high cost of feed. Mortality rates also have a major impact on costs. The cost of processing is a problem that needs to be addressed o the B.C. coast, since it is out of line with the cost in eastern Canada and other parts of the world.

Remote sites and the requirements for live haul are among the contributing factors. Offal loss, or the amount of fat in the viscera, can be reduced through proper genetic selection and proper diet, but at present we can do little to control this source of loss.

Less important factors are smolt price and insurance, capital investment, labour and administrative costs.

In B.C., the Atlantic salmon grow to over 3 kilograms in 14 to 24 months. The growth of chinook in the sea over a 24 month period produces a fish just over 2 kilograms. This gap between the performance of Atlantic and chinook salmon in net pens is closing. It remains to be seen how much we can improve the economic performance of chinook.

If we compare these production characteristics between Atlantic an chinook, note that we have a very small chinook smolt with a low cost. Investors originally thought that the low smolt cost would result in more profitable operations, but it hasn't worked out that way. The harvest weight is not as great as in Atlantic salmon, there is more control over maturation in Atlantics, and also higher survival. Higher stocking densities with Atlantics also contribute to a low cost of production.

The total costs of production for both Atlantic and chinook salmon are in fact very similar, but the higher market price for Atlantic salmon results in higher net returns to the farmer. The DPA economic model shows that the small size of chinook at harvest, results in low profitability for this species.

If I assume that the present low prices will rebound, chinooks will show a positive net return, but Atlantics with higher survival and market value will show better return on investment. The Atlantics are profitable under a much wider range of market conditions. Chinook will require a much tighter control of cost of production to show a profit. However, this is not to say that people farming Atlantics will have an easier time. Atlantics are much more susceptible to furunculosis and the ground water hatcheries that we use on this coast often produce imperfectly smolted fish. These problems have to be solved.

Dr. Ted Needham

In Table 5 we have made a rather spurious attempt to compare production costs from one country to the next.

Table 5. Estimated production costs for several major salmon producing countries.

International Production Costs (to the first point of sale)	
B.C.	$7000/tonne
Scotland	$6500 - 8000
Norway	$5500 - 9000
Chile	$5000 ?
New Brunswick	$6000

This work needs to be done in much greater detail in order to get good comparative data.

Table 6. Atlantic salmon production costs in Scotland. Data from the University of Aberdeen, North of Scotland College of Agriculture

	Shetland	Mainland
Smolt	18 %	22 %
Feed	26	14
Labour	15	14
Financing/ Depreciation	23	15
Harvest/ Processing	18	18
Cost per Tonne	$6500	$8000

The smolt cost is lower in Shetland because more fish survive. Feed costs in Shetland are lower because more fish survive and the food conversion ratio is better. Labour costs are about the same in both areas since both productivity and wages are higher in Shetland than on the mainland. Since Shetland is a more exposed area, the cages are more robust and require higher capitalization. Stocking densities in Shetland are 12 to 15 thousand smolts in a

15 x 15 x 10 meter Viking cage. The fish remain in the cage without grading or splitting and the survival is about 85 percent. Scotland sets up small processing units not more than 4 kilometres from each farm which accounts for very efficient processing. Table 7 compares the cost of production between the two areas.

The sale price per tonne is higher in Shetland because of the higher size range sold. A good measure of efficiency is the number of smolts required to produce a tonne of fish. Another very important measure is the earnings per smolt. Each business should develop similar measures of efficiency so that business can compare their production costs domestically and on the international market.

Table 7. A breakdown of grow-out costs to April, 1989 for the Shetland and mainland areas of Scotland.

	Shetland	Mainland
Cost/tonne	$6500	$8000
Sale/tonne	$7800	$7120
Margin	20%	-11%
FCR	1.6 - 1	1.9 - 1
Average Weight (Kg)	3.6	2.3
Survival	83%	72%
Smolts/tonne	308	588
Earnings/fish	$28.50	$17.00
Earning/smolt	$25.30	$12.10

Dr. John Spence

You have seen the dominating importance of the biological factors (Table 4). This industry in B.C., is very young. Where are we going over the next ten years?

There are many similarities between the broiler industry and the salmon industry. The cost of production in the U.S. broiler

industry has not changed very much (20 cents to 22 cents per pound) in spite of dramatic cost increases in production, value of the industry, capital costs and feed costs.

The cost of production was kept down by integration of companies. Fifty percent of the production comes from the largest 8 companies. (We are seeing a similar trend in the fish farming industry). Mortality rates and FCR has improved. There has been a tremendous reduction in man hours to produce a tonne of chicken. And, due to keeping the cost of production down, there has been a very substantial increase in per capita consumption in the U.S.

Major factors in the broiler industry cost of production have been better housing and management, nutrition and FCR, genetic improvements, vaccines and effective marketing.

The salmon industry has a very clear challenge, particulary from Chile, to keep the cost of production down.

Questions and Answers

Q - Is the DPA study available for the public?

A - David Egan and John Spence developed the model.

Q - The broiler industry has a very short life cycle and has control over the environment. How can we copy their experience.

A - There are analogies and differences. In our open pen systems we have little control over the temperature and other environmental factors. We need to locate in the optimum environment in nature. The ultimate determination on farmed fish is where you can put the farms. We are starting to identify the optimum sites. I the longer tem there may be innovative solutions to modifying the environment.

Q - Entech has developed a refined cost of production model that indicates coho will cost you money. Chinook is coming on strongly but does not have the same market value and for this reason is not as profitable as Atlantics.

A - Until we can produce farm based models, the figures we have will have limited value. Quality control is another difficulty with chinook salmon. Scale loss and other quality problems result in very poor quality Pacific salmon on the market. It is not surprising that our market price is lower. Effective quality assurance programs must be put into place.

Q - Up to this point, models indicate that Atlantic salmon grow faster in an absolute sense, but the growth rate between the two is the same, about 0.9 percent per day. The Atlantic salmon does not have a faster growth rate.

A - Smolt costs are not that important in overall production costs, so the fact that you start with a larger Atlantic Salmon smolt is an advantage.

Marketing of Atlantic Salmon

Knut Skabo
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I will give an overview of current market conditions for Atlantic and Chinook salmon, and some insight into the future pricing circumstances for salmon. For the last seven years we have marketed exclusively for the Scarfish group. We are associated members of the BC Salmon Farmers Association. We are associated with several farms in Sechelt and in New Brunswick.

It has been a turbulent 7 years. There has been concern for some time about the increased production of salmon in the world market place. I recall being worried that the market would collapse when the Norwegian production increased from 6 thousand tonnes, to 20, 30, 40 and 80 thousand tonnes. Today, Scotland is at 30 thousand tonnes, Norway is 150 thousand tonnes, eastern Canada at 5 to 10 thousand tonnes, and Chile about 5 thousand tonnes. The over production finally caught up with us and the price for salmon deteriorated in the last part of 1989. The selling of small, receivership fish at discounted rates also depressed prices in the short term.

Presently, Chile is coming to the end of their coho season and there will be some rebound in prices. There has been a small rise in 2 - 4 and 4 - 6 pound chinook. Most of the farms should have their salmon marketed by the end of the May so there is no competition with the wild salmon.

B.C. has a good reputation for small but high quality salmon. If quality improves, the price will rebound in the next weeks. There is a persistent problem however, with small size among chinook.

THE ATLANTIC SALMON WORKSHOP

The world market for Atlantic salmon has changed markedly in the last few months due to the initiation of a freezing program in Norway. The program of freezing a proportion of Norwegian production has been undertaken to stem the oversupply of salmon on the world market and to forestall further depression in prices. Out of 150 thousand tonnes, Norway is freezing 30 to 40 thousand tonnes in 1990.

For every kilogram of Norwegian salmon that a farmer sells, he will be levied an 80 cent fee to subsidize the frozen market. Excess production of frozen salmon will go to poor countries or be marketed in Japan through aggressive marketing campaigns. The product will not be sold at distress prices. The result of this initiative has been a firming trend in Atlantic salmon prices that can be expected to continue for 4 to 5 months.

The future for Canadian Atlantic salmon looks excellent. Norway production is levelling off and may even decline. The level of increased production that we have seen in the past will not be repeated. Eastern Canada's Atlantic salmon production is limited at about 10 thousand tonnes. Chile's production is somewhat unknown.

The proximity of B.C. production to the main U.S. market is a distinct advantage to the region. With expected stabilization in prices and increased consumption expected in the U.S. (imports to U.S. were 39 million pounds in 1988, and 56 million pounds in 1989), there is likely to be a stable opportunity for Atlantic salmon producers in the future. The Japanese consume 350 to 400 million pounds of salmon per year. The French have five times the per capita consumption of Americans.

For chinook salmon the scenario is different. This species does not grow fast enough. It may be uneconomic for many to produce this species. Production will go down but demand is likely to remain strong, so there should be a rebound in prices. One of the main problems is that the industry tries to market 80 to 90 percent of their production over a 2½ month period, particularly in April and May. If the industry could consistently produce a 4 to 6 pound fish of good quality, the price would rebound to about parity with Atlantic salmon. Size is the main difference between the price for Atlantic salmon and chinooks. Finally, one cannot over estimate the role of high product quality as a means of protecting price.

Another difference in marketing the two types of salmon is that Atlantics tend to go to the institutional and white table cloth market, while the chinook tend to go to the supermarket. Consequently, chinook prices tend to fluctuate more because they are in a more sensitive market area.

I would like to talk about the minimum price system in Norway. When the Fish Farmers Sales Organization was formed 7 years ago, we had a minimum price system established in order to protect market value. Minimum prices were established for each size group. Nobody could buy salmon for less than the minimum price. In order to buy salmon in Norway, a purchase licence issued by the sales organization is required. the Fish Farmers Sales organization guarantees the price to the fish farmer. If you bought salmon from a fish farmer, purchase confirmation is sent to the Fish Farmers Sales Organization. The purchaser pays the sales organization, which in turn pays the farmer. If the purchaser does not pay the organization, the farmer still gets paid.

This method worked well to begin with because the minimum price was lower than the market price. But when the market softened, the minimum price was lowered several times to accommodate the market. The minimum price system failed, and the freezing program was instituted. In the short term the system helped some people, but the free market still dictates price.

In conclusion I am optimistic of firmer prices and less volatility in the future. When production balances demand more closely, it will be easier for us to operate in this complex world of salmon.

Questions and Answers

Q - Could you comment on the price difference between the different size classes of fish?

A - The main reason for lower prices in the 2 to 4 pound range is that production of salmon in that range is higher. Since everyone is basically competing in the same market, there is going to be downward pressure on prices in the areas of strong supply. If we had more 4 to 6 pound product the spread would be less. Another problem is the short period of time in which the product is being marketed. The 6 to 9 pound salmon is competing with Atlantic salmon and coho from Chile. Chile markets in the period from January to March. There really isn't a particular market for grilse or jacks. You simply have to move it as a byproduct, it is hard to market it in large volumes.

Comment: The salmon farming industry is getting to the point that it will have to look at other more mature industries to see what to do beyond this point. We are not only competing with other salmon products, but are competing with other meat products. We have to find ways to compete successfully against poultry and beef. One of the strategies may be to put out a wider range of aquaculture products. Other industry experience, such as rainbow

trout and catfish, indicate that a wide range of products assist in the movement of tonnage.

Reply: Up until about a year ago it was very easy to move salmon. In fact there was always a shortage of salmon, we simply needed to place the product. Now we have to find different avenues of sale.

Q - Top quality chinook salmon tend to be redder than Atlantic. How will this affect marketing?

A - If you can improve the colour, you will get a better return than average.

Northeast U.S. Atlantic Salmon Farming Industry Current Practice and Marketing Objectives

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The first known commercial aquaculture firm to engage in salmonid pen culture at sea in Maine is believed to have been Fox Island Fisheries, which started a small coho salmon and rainbow trout pen operation off Vinalhaven in 1973-74. At that time, no lease was required. The first lease issued by the Maine Department of Marine Resources for salmonid aquaculture (among other species), was granted to abandoned Farms Inc., in 1981, for a site in the Damariscotta River, which was subsequently used mainly for shellfish culture. In 1982, Ocean Products Inc. started operating in Eastport, Maine, and became the first successful large-scale salmon farm in Northeastern U.S.A. Since then, the number of commercial salmonid pen culture leases in the Northeastern U.S. has increased rapidly, from 1 lease in 1981, to 2 leases in 1985, 21 in 1987 and 36 in 1989. The 36 commercial leases in the Northeastern U.S.A. include 31 distinct sites (geographically separated), 18 of which were operational as of summer 1989. In addition, there were nine operational hatcheries in the region, and one just starting up. A total of fifteen firms, (of which two operated hatcheries exclusively) were operational at the time. The industry is smaller than in the Pacific northwest, but is still an economic force in the area.

Last summer and early fall 1989, we performed a farm survey of sea cage aquaculture sites and hatcheries that include 14 of the 15 operational firms (see Table 1). There were more than 220

full-time employees and 70 part-time employees in the industry, in both grow-out operations and hatcheries. Over 100 of the full-time employees are with the firm Ocean Products, Inc. Only 3 out of 14 operational firms had been in operation for over three years at the time of the survey. Over half of the responding firms claimed some foreign ownership, predominantly Norwegian or Canadian.

Table 1. Commercial salmonid sea-cage aquaculture in the northeastern U.S.A.: Number of sea sites and hatcheries (summer of 1989).

Sea sites	
Total number of leases[1]	36
Total number of production sites[2]	31
Operational sites[3]	18
Hatcheries	
Total number of hatcheries[4]	10
Operational Hatcheries[5]	9
Total number of operational sites	15

1 including 35 leases in Maine and 1 in Massachusetts
2 A production site is defined as a geographically delimited sea area where cages can be installed. Adjacent leased areas are considered a sole site.
3 An operational site is defined as a production site with fish (smolts or adults) in the water at the time the survey was conducted, even if no harvesting had occurred. The above figures include two sites used only for holding smolts and not operational during the winter months.
4 Includes an egg-incubating facility (green to eyed eggs); a parr-smolt facility; and a hatchery which raised juveniles to the parr stage but was fully equipped (and planned) to start producing smolts.
5 Operational hatcheries are defined as having live fish in the water.

Only commercial operations are listed. Federal and State hatcheries, as well as sea sites used for research purposes, are not included.

For the grow-out operations, production volume has been increasing rapidly. In 1988, the total industry production was between 560 and 650 tonnes, in 1989 between 1,440 and 1,650 tonnes and in 1990, production is expected to be between 4,100 and 4,840 tonnes. Of the total, rainbow trout accounted for 180-240 tonnes in 1988, 90-150 tonnes in 1989 and 100-140 tonnes in 1990. The remaining was Atlantic salmon. Maine produced salmon is expected to become a significant market factor in the northeastern U.S.

THE ATLANTIC SALMON WORKSHOP

Atlantic salmon smolts are transferred to sea from April to June. A 33 to 85g smolt sells for $2.50 to 3.25 U.S., and larger smolts (85 to 200 g) sell for about $3.50 to $3.75 U.S. Smolts were said to account for approximately 14% of the operating costs.

For the grow-out, feed was said to cost 38 cents U.S. per pound for Connor's moist diet, and between 50 and 67 cents U.S. for dry diets provided by Moore Clark, Shur Grain, Corey Feed, EWOS and Zeigler, according to farmers. The reported prices for dry feed may abe slightly inflated, as feed manufacturers claimed prices ranging from 44 to 54 cents per pound, including delivery to the Eastport-Lubec area. While smaller operations generally use moist feed, most of the larger firms have adopted dry diets, which currently account for about 70 to 90% of the total used by the industry . Feed costs were said to be between 20 and 55% of the total operational costs.

Expect FCRs for dry diets ranged between 1.3 and 1.75:1 and for moist feed between 2.0 and 2.5:1. These should be viewed as producers' expectations rather than actual rates, which may be higher (i.e. less efficient) in particular for dry feed.

Based on the survey, production costs for Atlantic salmon ranged between $2.10 and $3.00 U.S. per pound, and for rainbow trout between $2.10 and $3.00 U.S. per pound, after gutting. FOB prices received for salmon in 1988 were said to be between $4.00 and $5.00 per pond. Following the general price drop in the salmon market during 1989, the price of gutted salmon in the Eastport area is said to have dropped as low as $2.98 per pound during late November and early December, increasing thereafter to about $3.95 to $4.05 per pound in March. Rainbow trout is known to have commanded prices a high as $4.50 per pound (FOB) during 1988, but more commonly prices ranging from $3.00 to $4.00 per pound were referred for the pre-1989 period, and lower thereafter.

Water quality was said to be excellent at all sites surveyed, but there were some problems with shelter and water temperatures. In particular, there is risk of super-chill in areas less protected than the Eastport-Lubec region, where a combination of high tides and strong currents provides a vertical mixing of the waters that acts as a buffer for extreme temperature variations. Accessibility was rated as excellent for most sites. Risks to the environment were said to be minimal, again because of the strong currents prevalent in most regions where pens are installed, and which provide adequate flushing. Nonetheless, some opponents of the industry feel the risk is greater.

In the past, one of the main problems faced by the industry

was the shortage of Atlantic sea-run smolts, which hindered production growth and forced most of the existing firms to cultivate landlocked strains of salmon and rainbow trout as substitutes. This constraint seems to have been lifted in 1989 as more hatcheries came on line with commercially available smolts. Problems with feed supply were said to be minimal. In relation to labour, four out of twelve firms cited past difficulties in finding skilled local labour. Commenting on it, one operator specifically mentioned a shortage of skilled U.S. workers in cold water aquaculture.

Currently, the biggest constraint faced by the industry may be permitting. In the current environment, it may cost a firm no less than $100,000 U.S. to apply for a lease and seek all the necessary permits, including legal fees and fees paid to consultants. Regulatory constraints, as well as the growing scarcity of new, quality sites, was a major factor accounting for the reduction in the number of leases granted for salmonid aquaculture by the Maine Department of Marine Resources in 1989 (2 leases, as compared to 13 leases granted in 1988 and 14 in 1987).

Most firms expected the industry to expand production beyond the current levels. There were mixed feelings among the farmers as to whether output prices would increase or decrease in the near future. By contrast, the cost of smolts and eggs was expected to go down in the region, due to a stronger competition among the hatcheries.

Harvest occurs generally from November to February. Most of the product (over 98% according to the survey) is sold fresh. The remaining is frozen. If marketing plans remain unchanged, and according to farmer's expectations, between 70 an 81% of the 1990 production will be sold on a head-on, gill-in, gutted form, with head-on, gill-out accounting for 2 to 12.5%, and whole, ungutted accounting for approximately 14.5%. A minimal amount is sold in an head-off or fillet portions form. This relates to the processing form adopted by the firms at first sales only. Some of the salmon is known to be further processed, namely for smoking.

According to the survey, wholesalers and/or processors account for about 75 to 84% of the direct sales. An estimated 14 to 20% is sold directly to supermarkets and 3 to 5% to restaurants.

Recent price drops in the market for salmon have occurred, partially due to the strong supply of sockeye and pink salmon from the wild fisheries in 1989, the large supply of farmed salmon, a stronger dollar, and a change in Japanese consumption patterns. Nonetheless, there are still additional market opportunities, especially for value added products.

Quality and performance of marketing at the retail level is also important. In a recent trip to a supermarket belonging to a major chain in New England, I tried to purchase some Atlantic salmon, but because the store clerk who usually cuts the salmon was not there, I could not purchase a fillet. I could not buy the fish even after I had completed my shopping and had returned to the fish counter. I imagine a significant number of sales are lost because of poor marketing.

Questions and Answers

Q - How many smolts are going into the water this year?

A - In the spring of 1989, approximately 2 million smolts were transferred to sea pens in Maine. The numbers for 1990 are expected to be in excess of 2.5 million.

Q - What is your comparison of the cost of production in different countries, from your perspective?

A - I can comment only for cost of production in Maine. With favourable transportation costs (due to proximity to the U.S. northeastern market), even under present circumstances Maine farms are in a relatively good position.

Q - What is the processing cost per pound in Maine?

A - Processing costs average around 20 cents per pound for a head-on, gill-in, gutted fish, when a processing plant is contracted out. An additional 10 to 20 cents per pound is spent on packaging and about 5 to 10 cents per pound is spent on transportation from the Eastport-Lubec region to the Boston area. Overall costs for processing, packaging, transportation and marketing average about 50 cents per pound of fish, but they can be less for a firm owning its own processing facilities. Processing and marketing costs were said to average between 6% and 20% of the total operational cost.

Q - How are you going to prevent prices from dropping when Norway floods the market with frozen product later in the year?

A - I think there are still market opportunities. However, there is not a clear strategy for dealing with that problem. I do not expect the U.S. anti-dumping duties to be in effect this year. It may be an option for the long term.

Q - The quoted trout price ($4.20) was higher than the price for salmon ($4.00) on one of the overheads.

A - That was probably an error in the overhead. It may have been a special deal. This was not a weighted average so it may be seriously skewed if a farmer quoted an inflated price. According to a producer, rainbow trout prices are generally lower than prices of salmon, but several farmers quoted receiving prices for rainbow trout that were comparable to past prices received for salmon, in the $4.00 -$4.50 U.S. per pound range, before the price drop of 1989. We also know that there has been some rainbow trout (particularly of the Donaldson strain) that has been sold as salmon in the past.

Knut Scarbo: Rainbow trout is looked upon as a lower priced product than salmon. But isolated jumps in demand for salmon trout can inflate the price.

Q - Has anyone considered the implication of quotas to regulate the market supply and keep prices up?

A - I doubt that you would see import or production quotas in the U.S. in the foreseeable future.

Ted Needham: Small salmon sell for about the same price as trout. When the market collapsed last year, salmon didn't get a better dollar than trout. Atlantic salmon sell at a better dollar because they are bigger. If the market fails, there is a compression of price per pound among size classes and large fish loose their advantage.

Q - If we could deliver better looking salmon, and more value added can you estimate what the market might be?

A - The market hasn't changed much in terms of the way salmon is marketed. The demand hasn't changed with value added products. The demand can still grow, perhaps as much as 30 percent or more if the right product hits the right person. In terms of total tonnage, I couldn't guess at it now. There is definitely a need for better marketing.

Jim Anderson: We have calculated some future production levels. If all the firms meet their expectations, we expect in excess of 12,000 tonnes. If in addition all of the current leases (some of which have not secured all of the necessary permits), become operational, the production will be in excess of 15,000 tonnes. There are problems with expansion, including the permitting procedure, problems with finding capital and marketing.

Q - How many smolts does it take to produce each tonne of Atlantic salmon in Maine?

A - Assuming a 15% mortality and an average weight of 6.5 to 7 pounds per fish at harvest, it would take between 360 and 390 smolts to produce a tonne of salmon. At these rates, the 2 million smolts stocked in 1989 should produce 5,000 to 5,500 tonnes by 1990. Our estimates for 1990 are lower than this, in the order of 4,100 to 4,840 tonnes, because mortality rates were higher than expected during 1989, primarily due to selective grading.

Q - Is there a market for chinook salmon in Maine?

A - We have not seen much chinook here. We see mostly Atlantic salmon from several sources and some coho from Chile.

Q - We see whiter flesh colour among Maine Atlantics. Do you see this continuing or do you see an improvement in the colour.

A - There are pigment restrictions on feed used in the U.S. and some firms may be reluctant in using pigments in their diets. Farms have not reported discounts due to light flesh colour in their product. The colour of Maine salmon will probably improve as several new firms, using different combinations of feed, place their fish in the market in 1990.

Q - To Dale Blackburn: What do you think the proportion of chinook versus Atlantic salmon will be in the industry in the future?

A - (Dale Blackburn) - Last year there was little demand for Atlantic smolts, this year we cannot supply the demand. I think that indicates the level of interest in the industry this year.

Q - What are the top loss factors among Atlantic salmon in Maine?

A - Farmers cited mortality rates between 5 and 20 percent. Most is due to natural mortality (in particular smolt acclimatization), predation (seals), induced mortality (selective grading), superchill, vibriosis and furunculosis. Mortality rates tend to be low among most firms, but it is still too early in the development of the industry to confirm this. There have been to date no significant problems reported with algal blooms and sea lice problems.

Q - What do you think of marketing Atlantic salmon as "King" salmon?

A - I think there would be a real problem trying to change the name of Atlantics to King, but some may try it. However, there would be most likely some potential legal problems.

History of Atlantic Salmon Imports to the West Coast Since 1983

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First, I will give an overview of the commercial catch statistics for Atlantic salmon by west coast commercial fishermen. I must caution that I do not have the details on how these statistics were collected and that the figures are estimates.

In 1988, 206 Atlantic salmon were captured in Washington state waters (the largest fish weighed 10 kg), and 106 in British Columbia (total B.C. catch was 800 kg). In 1989, 51 Atlantic salmon were reported captured in Washington state and at least 8 in British Columbia (B.C. data is incomplete).

In 1983, Brad and June Hope became interested in the success of Atlantic salmon in other parts of the world. At first, the Hopes and IBEC Aquaculture Ltd. considered a joint venture to bring the Atlantic salmon to B.C., but the partnership never materialized. Both groups eventually did import the species to B.C. in 1985, the Hopes to Hotham Sound, North of Sechelt, and IBEC to the Kokish River site near Port McNeill.

Many questions were initially raised concerning the introduction of the Atlantic salmon to this coast. Questions arose regarding compliance with the International Council for the Exploration of the Seas, which requires that member countries consult with the council prior to the introduction of new species. Concerns were voiced regarding the potential for undesirable ecological interaction with native salmon in the event of inadvertent releases of the Atlantic salmon. There were concerns about the possible cross-breeding of Atlantic salmon with steelhead, and about the possibility of introducing disease or undesirable plants and animals. Commercial fishermen, sports fishermen and trout growers voiced concerns centred on the possible competition for spawning ground between Atlantic salmon and native salmonids.

A number of measures were considered to address these concerns. By allowing fertilized eggs only to be imported, the risk of inadvertently introducing other plants and animal species, such as aquatic weeds and fish parasites, can be reduced. The surface of the egg can be disinfected, thereby reducing the possibility of introducing many important fish pathogens. The number and size of each shipment also needs to be considered. In addition, geographical areas from which shipments would be accepted needed evaluation. As well, the time over which imports would be accepted and the number of locations to which shipments would be allowed were considered, along with procedures for handling the imported fish once they arrived.

In summary, among other things, risk management associated with the introduction of the species must consider:

1. the species involved
2. the number of shipments and their size in terms of the number of animals
3. the number of sites from which shipments are received
4. the geographical location of these sites
5. the time over which the shipments take place
6. distribution of the animals after their arrival
7. age of the animal
8. controls placed on the species after arrival
9. impact evaluation

Based on these, a number of conditions were adopted. The most important were:

1. Only fertilized eggs would be allowed into the province.
2. There must be compliance with the Canadian Fish Health Regulations.
3. The number of shipments would be limited.
4. The number of source and receiving facilities would be limited.

5. Quarantine procedures would be implemented at the destination.

Unfortunately, the lack of success of the early attempts to establish Atlantic Salmon on the coast, which involved gravel plantings of eggs and fry releases, did not answer questions regarding the survival and subsequent success of juveniles or adults inadvertently released from hatcheries and sea cages.

In 1984, all groups interested in importing Atlantic salmon eggs into B.C. were asked to name and jointly agree to a single egg source and to adhere to the conditions listed above. Scotland was finally identified as the most desirable source, the first imported stocks came from the Sterling University. Later, the Alt Mor and Mcconnell salmon hatcheries in Scotland also met the Canadian fish Health Protection Regulation standards and were allowed to ship eggs into B.C.

The first shipment of Atlantic salmon eggs after 1983, arrived in 1985. Table 1 outlines the numbers introduced from 1985 to 1989.

In each case the eggs originated from a source certified according to the Canadian Fish Health Protection Regulations and were quarantined upon arrival in B.C.

Table 1. Total Atlantic salmon egg imports to B.C. from 1985 to 1989.

Year	Number of Eggs	
1985	130,000	(20,000 to Pacific Biological Station)
1986	1,172,000	
1987	2,550,000	
1988	2,700,000	
1989	500,000	
	7,052,000	

Table 2 gives the source of the imported Atlantic salmon eggs and the number of permits issued between 1985 and 1989.

Table 2. Source of Atlantic salmon egg imports to B.C. from 1985 to 1989.

Year	Number of Permits	Source
1985	4	Scotland
1986	3	Scotland
1987	10	Scotland, U.S.A.
1988	10	Scotland, U.S.A.
1989	3	U.S.A.
TOTAL	30	

The Quarantine procedures required the isolation of the Atlantic salmon from other species, the disinfection of discharged water from the facility, and four additional fish health checks over twelve months.

The companies that imported Atlantic salmon eggs between 1985 and 1989 in compliance with the quarantine conditions are:

Pacific Biological Station, Nanaimo
IBEC Aquaculture Ltd., Kokish River Site
Tidal Rush Marine Farms, Hotham Sound
Pacific Aquafoods, Port Alice
Norwegian Enterprises, Quadra Island
Sea Farm Canada, Sayward
Rosewall United Hatcheries, Rosewall Creek
Freshwater Farms, Duncan

Since 1983, the Department of Fisheries and Oceans has received many requests to allow Atlantic salmon as well as other species of finfish into B.C. for aquaculture purposes. To clearly establish the conditions under which Atlantic salmon eggs would be allowed into B.C., the Federal/Provincial Policy for the Importation of Atlantic Salmon in B.C. was implemented in 1987. The objective of the importation policy was to reduce the risks associated with repeated large scale shipments into the province and to meet the public's concerns.

The policy states that after March, 1989, large shipments of Atlantic salmon eggs for production purposes will not be permitted, but importation for research and breeding purposes could be approved. Again, only fertilized eggs will be allowed, the Canadian Fish Health Regulations must be followed, as well as the quarantine procedures. No eggs are allowed from VHS positive

countries. Requests must go before the transplant committee and importation of small quantities of eggs and milt for stock development an improvement may be allowed.

Questions and Answers

Q - I have heard that egg mortality has been very high, about 60 percent of the eggs taken this year. There is concern about the impact on the industry in two years.

(Directed to the floor, no response.)

Q - Is milt permitted under the policy?

A - Yes

Q - Is there a limit on the number of eggs that can be imported?

A - To some degree that is negotiable, the policy simply states small numbers will be allowed.

Q - What are the transplant regulations for moving Atlantic salmon from hatcheries to sea sites that are not presently licensed for Atlantic salmon?

A - Atlantic salmon are handled in the same manner as other species. B.C. is divided into seven zones and species cannot cross zonal boundaries without approval. Facilities must be licensed for the species in question, so a management plan would have to be amended.

Q - What are the guidelines for Atlantic salmon on a site?

A - As long as there is no significant increase in the production level, the site will be approved.

Q - What are the ecological risks associated with the Department of Fisheries and Ocean's decision to allow Arctic Char into the province? Was the ban on importing St. John River stock from New Brunswick into Newfoundland made on the same basis as B.C. decisions?

A - The situation on this coast is totally different from the situation on the east coast. We have not prohibited the

importation of St. John River stock to B.C., they have different concerns from ours. There is less concern voiced with the importation of Arctic char into B.C., they originate in the North West Territories and are a Canadian Species.

Comment: Atlantic salmon have been turning up in the sports catch, but I don't have reliable figures. I do, however, have concern about Arctic Char being imported into B.C.

Guidelines for Lake Net-Pen Rearing of Atlantic Salmon Smolts

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We'll touch on the concerns of the Ministry of the Environment, the development of the guidelines as they are now and what is currently being considered. As lake pen rearing became a reality, we developed a set of guidelines for Vancouver Island only, then decided to extend the guidelines to the rest of B.C. We took our guidelines to the small lake committee which canvassed the rest of B.C. and came up with the following list of problems. These problems have mainly to do with disease, fishery management concerns, and the impact of lake pen rearing on the environment.

The lake guidelines developed for Vancouver Island dealt with 4 areas: angler effort (limit of less than 10 angular days per hectare per year), fish populations (kokanee and disease transfer, unique stocks), physical and chemical properties (environmental impact) and licensing (all licences in place before nets in the water). We also wanted to restrict pens to lakes with no domestic water supply use. The Small Lakes Committee is reviewing these guidelines in terms of their applicability to the rest of B.C. They are presently at the Directors office for review and will probably be used on Vancouver Island initially on a pilot basis.

The operational guidelines that the Small Lakes Committee came up with are listed:

1) The cultured species must undergo transplant committee review and disease inspection.

2) Site selection will be assessed on the basis of the number of sites per lake (one per lake is recommended). The water depth must be

greater than 20 meters and must be at least one kilometre from a spawning stream. The lake size must be greater than 200 hectares.

3) Operational requirements include a predator proof pen, an approved operational layout, water quality and disease monitoring.

4) There is provision for public input on the proposal.

The fish management concerns are:

1) Potential for disease transfers between wild stocks.

2) The licences must be in place.

3) The environmental impact must be monitored.

4) Fishery management impacts, that is interactions between the net pen operator and the fishermen.

Questions and Answers

Q - How many applications are presently under review?

A - Two are under review right now. The existing facilities are all licensed. The ones under review are not sited.

Q - Has any information been gathered on the present Ministry of Environment net cages that have been in place for several years? Can information from these studies be used to determine what the impact of commercial lake net pen operations might be?

A - No, I don't know of any.

Q - One of your facilities at O'Connor Lake, is located in a lake that is well under the minimum size indicated in your guidelines, yet as far as I know there is no environmental impact.

A - Well, you don't know that there isn't environmental impact. A literature review has been done.

Q - Are there any lakes approved for the rearing of Atlantics?

A - Georgie Lake on the north of Vancouver Island is approved. That was in place before the guidelines were developed.

Q - A lot of the large, deep water lakes have sockeye populations. In the future, could any areas in those lakes that are well away from the beach spawning sites or streams be allowed for net pen culture?

A - No, not now, might be possible in the future. The policy is under review.

Q - There is a Kokanee population in Lake Cowichan where the Ministry of the Environment has a net pen operation. Have you any evidence that the steelhead have picked up IHN?

A - They are checked for IHN, but we don't know if it has been picked up.

Comment: The question of whether IHN could be picked up and moved to the ocean requires further study.

Q - Could you be more specific about disease concerns of net pens in lakes?

A - We are concerned that new diseases, previously not in the lake, may be introduced. Also, that IHN could be picked up by cultured fish and moved out of the lake into another facility.

Q - Could you comment on the development of Atlantic salmon lake pen rearing?

A - There really aren't any differences in our consideration of Atlantic salmon or other species. As long as the transplant committee guidelines and other Department of Fisheries guidelines are followed, we wouldn't have further considerations.

Q - In Scotland, the 70 freshwater cage sites have potential for considerable impact in that small country. There were extensive government and industry consultations prior to the drawing of guidelines. Will that be done here?

A - That consultation has occurred here, but more with the client group of our Ministry, which is the fishermen.

Comment: There are many more freshwater fishermen than farmers and so their concerns must be considered. Part of the process is occurring here, the industry must provide input to address their concerns. We should assess the impact of these regulations.

Q - What are the guidelines for importing Arctic char and are they under review?

A - The Fish Health Protection regulations must be followed. The proposal is put before the Transplant Committee, constraints may be imposed by the Ministry of the Environment.

Q - Will the Ministry of the Environment consider putting Atlantic salmon in rivers for their client group (sport fishermen)?

A - No

Q - Would the Ministry of the Environment be interested in using a private lake for environmental impact studies?

A - No, we have enough cages established in public lakes to carry out such a study.